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ARCHIVES OF SURGERY

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ACTINOMYCOSIS IN THE UNITED STATES*

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In a former report on the distribution of actinomycosis in the United States, we stated that our complete protocols of case reports obtained from various sources would be published as a geographic index of the disease in this country. The data are arranged geographically, the forty-eight states being grouped according to the usual method. The case reports for each state are subdivided into those that have been published previously and those that have not been published previously, but which have been reported to us, either as a response to individual letters of inquiry to health officers or the larger hospitals, or in reply to requests for such data published in various medical journals. Another group of case reports is made up from the records of the Mayo Clinic. The total number of cases studied is 670. All cases reported in the literature that were included in Ruhräh's review are marked with an asterisk.

SUMMARY OF CLINICAL FINDINGS

Nearly 80 per cent. of the persons affected were males. There is no question of the fact that more men are affected than women. They are probably more often exposed to the disease in nature, and are not so particular in their personal habits regarding the care of their mouths.

The age incidence is of interest. The youngest patient on record was reported by Stokes, of Baltimore, an infant 28 days old that died of marasmus. Actinomycosis was found in the pus from an abscess in the lower left lobe of the lung. There were two patients 82 years old. One of these, reported to the Minnesota State Board of Health by Ahrens of Bellingham, died from actinomycosis of the chest after an illness of ten years. The other patient contracted actinomycosis of the neck in Iowa, which lasted two years. He was treated until his death by Sogge and Johnson of Windom, Minn.

The median value for the age incidence falls between 20 and 30 years; accordingly, this is a disease of young adults. However, there were twenty-two patients between the ages of 1 and 10 years,

* From the section on clinical laboratories, Mayo Clinic.

and seventy-one between 10 and 20. Actinomycosis is therefore a disease to be considered among those of children and youths.

The anatomic distribution of actinomycosis was also thoroughly reviewed in the early work of Ruhräh. At that time, the work of Poncet and Bérard was considered the criterion for the study of the anatomic distribution; the American case reports did not indicate that actinomycosis was found in all the regions of the body reported by the French authors. In our present group, however, are included all the portions of the body mentioned in the classification of Poncet and Bérard, except the esophagus and lachrymal ducts. Other locations also are included. This distribution is briefly summarized as follows:

Nearly 60 per cent. of the cases occurred in the head and neck, being about equally divided among the jaw (not involving the bone or periosteum), the neck (submaxillary, submental and cervical regions) and the face (temporofacial region). Slightly more than 18 per cent. were abdominal, involving the wall or cavity, the intestines, appendix and liver. There also is on record one instance of the gallbladder being involved. The thoracic type was found in almost 14 per cent. of the cases, the chest wall and lungs being the chief locations; in four cases, the ribs or vertebrae were infected, and in one case there was involvement of the mediastinum. The rarer forms of the disease include the subcutaneous or cutaneous type, three cases; involvement of the pelvis, nine cases; of the gluteal region, five; of the perirectal region, five; of the scrotum, four; of the arm and forearm, three; of the hand, three; of the extremities, two; of the finger, two; of the thumb, two; and of the perineum, the foot, the heel, the thigh, the ovary, the tubes, both the tubes and ovaries, the kidney, the bladder, the testis and the penis, one each. There were thirteen cases of general involvement in which there were various combinations of locations, including the face, thorax and abdomen.

It is thus seen that practically every part of the body may be attacked by this disease, although the head and neck are most often involved, and next most often the alimentary tract and abdomen. The mouth is the chief atrium of infection.

Actinomycosis may be acute, subacute or chronic, the symptoms lasting from one week to fifteen years. Baskin reported a case of actinomycosis of the left hand which occurred in Nebraska, in 1919, in which the lesion was of one week's duration when the organism was demonstrated, and which healed in two weeks. The Mayo Clinic records show that a Minnesota patient had symptoms of actinomycosis of the anterior chest wall and upper part of the abdomen for more than fifteen years.

Occupation is an etiologic factor that must always be considered in this disease. It is evident that, while approximately half the persons

infected with actinomycosis have lived in rural communities, and often have come in direct contact with cattle in their occupation, there are as many others that have never come in contact with cattle. It is the general opinion that the infection is obtained from nature by man in much the same manner as by cattle, by the inoculation of spore forms from vegetation, often as the result of the introduction of a foreign body into the soft tissues. There are numerous cases in which the onset of the disease seemed to be related to an injury. The difficulty of culturing the organism and of its experimental study in laboratory animals has greatly handicapped the complete bacteriologic study of this disease, and our knowledge has advanced but little in this respect since the early investigations of Israel, Ponfick and others, nearly fifty years ago.

We wish to make special mention of the interesting and valuable information furnished by Luckett of New York City, who has been interested in this disease, both in man and cattle, since 1891. He makes one statement that seems to hold in all parts of the country: that actinomycosis of the bone is very rare in man. In the Mayo Clinic, we have no record of the involvement of bone. Solis Cohen of Philadelphia, Minges of Dubuque, Iowa, Evans and Gunderson of LaCrosse, Wis., Schoregge of the Bismarck Clinic, Bismarck, N. D., and Webber, epidemiologist of Massachusetts, furnished very complete and interesting data for the preparation of this study. The information sent us by Warthin, while not definitely arranged, is of great interest as it concerns the incidence of the disease in Michigan. The work of Minges is historic. From a patient with actinomycosis whom he saw in 1892, he obtained "sulphur granules" with which he was able to infect a white rat by planting a single colony in the peritoneal cavity. Many nodules and ulcers were formed. The rat was kept alive for eighteen months, potassium iodid being administered in milk. At one time, a nodule appeared on the jaw of the rat. Attempts to inoculate laboratory animals in this manner usually end in failure.

As we have before stated, actinomycosis is distributed widely in this country, being especially prevalent in the upper Mississippi valley and the northwest portion of the country. It is far more common than one is led to believe from the scattered reports that have appeared in the American literature. This fact should make all physicians more alert in the diagnosis of the disease, which is very easily made from a microscopic examination of the discharges. The public generally might be warned of the danger of chewing straws, weeds and grain, as a possible means of infection with actinomyces. Much is yet to be learned, however, with regard to the source of infection in man and animals, and also much is to be done in the proper classification and the bacteriologic investigation of the different species in this group.

NEW ENGLAND STATES

Maine

Year	Author	Source	Sex†	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1908	A. L. Sawyer, Ft. Fairfield.....	Reply to letter in Maine M. J.	♂	19	Farmer	Ft. Fairfield	Back and abdomen	2 years	Died
1910	C. F. Kendall, Augusta.....	Report from Health Office.....	?	?	?	Aroostook Co.	?	?	Died; very meager data
1911	A. L. Sawyer, Ft. Fairfield.....	Reply to letter in Maine M. J.	♂	17	Farmer	Ft. Fairfield	Bowels	2 years	Symptoms of appendicitis; autogenous vaccine; no benefit; died
1914	C. F. Kendall, Augusta.....	Health Office	?	?	?	Aroostook Co.	?	?	Died; very meager data
1916	C. F. Kendall, Augusta.....	Health Office	?	?	?	Waldo Co.	?	?	Died; very meager data
1918	C. F. Kendall, Augusta.....	Health Office	?	?	?	Cumberland Co.	?	?	Died; very meager data
1910	A. L. Sawyer, Ft. Fairfield.....	Reply to letter in Maine M. J.	♂	?	?	New Brunswick	(Canadian case; not counted)		

Department of Animal Industry writes: Fraction of 1 per cent. of animals have actinomycosis.

New Hampshire

Health Officer: No data.
State Veterinarian: Disease is not prevalent among cattle of state, though it does occur.

Vermont

Year	Author	Source	Sex†	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1922	W. C. Clark.....	Presbyterian Hospital, Columbia Univ., New York City	♀	23	Nurse	Burlington	Tonsils	?	Tonsillectomy; actinomyces in tonsillar crypts

Health Officer: No cases.
State Veterinarian: One case in twenty years.

Massachusetts

Year	Author	Source	Sex†	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1894	Mallory, F. B.*.....	Boston M. & S. J. **132**: 296-300, 1895	?	..	?	Boston (Dane)	General	3 months	Ruhräh, Case 40; lump in epigastrium; spreading tumors to ribs, arms and shoulders; first diagnosis tuberculosis; later actinomycosis; died
?	Mixter, S. J.*.....	Boston M. & S. J. **132**: 303-304, 1895	♂	60+	?	Boston	Abdomen	?	Ruhräh, Case 53; fishbone may have been cause of primary lesion; actinomyces in pus; never was associated with cattle
1895	McIntire, J. B.*.....	Boston M. & S. J. **136**: 84-86, 1897..	♂	51	Merchant	Massachusetts	Subcutaneous (?)	7.5 months	Ruhräh, Case 57; died
1895	Codman, E. A.*.....	Boston M. & S. J. **139**: 134-135, 1898	♂	48	Straw hat factory	Boston	Wall of chest	?	Ruhräh, Case 34; sinus; actinomyces present; pulmonary hemorrhages (unusual); potassium iodid given; improved
1899	Munro, J. C.	Boston M. & S. J. **143**: 255-256, 1900	♂	45	Clothing dealer	Boston	Lungs and chest	?	Actinomyces in sputum and in pus from sinuses
1900	Munro, J. C.	Boston M. & S. J. **143**: 255-256, 1900	♂	35	Carpenter	East Boston (Prince Edward Is.)	Neck	1 year ?	Struck cheek against a board
1900	Munro, J. C.	Boston M. & S. J. **143**: 255-256, 1900	♂	35	Carpenter	Boston	Jaw	?	Jaw broken in fight 32 months before; fell 10 days before, striking face
1900	Munro, J. C.	Boston M. & S. J. **143**: 255-256, 1900	♀	?	College girl	Boston	Jaw	?	
1899	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900 (Mass. Gen. Hosp.)	♂	32	Coachman	Boston	Jaw	5 weeks	
1899	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	♂	45	?	Boston	Jaw	?	Occurred 2 months after injury under the tongue with a toothpick

* Cases included in Ruhräh's review: Ruhräh, J.: Actinomycosis in Man, with Special Reference to the Cases Which Have Been Observed in America, Ann. Surg. **30**: 417-451; 605-631; 722-746, 1899; **31**: 235-241, 1900.

† In this table, ♂ indicates male, ♀ female.

1899	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	♂	16	Schoolboy	Boston	Jaw	2 months	Poor teeth
1899	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	♂	30	?	Boston	Jaw	5 months	Began about molar tooth
1899	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	♂	22	?	Boston	Jaw	5 weeks	
1899	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	♂	20	Laborer	Boston	Jaw	3 years	
1900	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	♂	?	?	Boston	Jaw	6 months?	Broke lower left jaw; this healed, but whenever drunk a swelling appeared at point of fracture
1900	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900 (Dr. G. W. Brewster's case)	♂	40	?	Boston	Jaw	2 years	Carious molars on left side
?	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	..	..	.....	.....	Jaw	.....	No data
?	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	..	..	.....	.....	Jaw	.....	No data
?	Porter, C. A.	Boston M. & S. J. **143**: 251-254, 1900	..	..	.....	.....	Lung and ribs	.....	No data
1905	Scudder, C. L.	Boston M. & S. J. **172**: 639, 1915....	♀	49	?	Boston	Abdomen (umbilicus)	12 years?	Tumor on umbilicus removed; fishbone 5 cm. long in mass; gave history of swallowing fish bone 12 years before; actinomyces in bottom of sinus; fishbone had passed through the colon
1912	Steele, A. E.; Lee, R. I.	Boston M. & S. J. **169**: 502-503, 1913	♂	19	Schoolboy	Jamaica Plains	Lungs	7 months	Gram-positive, acid-fast Nocardia in sputum
					PERSONAL LETTERS				
1907	Dept. Public Health, Boston...	Department Health Report §	♀	33	?	Massachusetts	Liver and wall of chest	?	Incision and drainage of lumbar abscess; much relieved
1907	Dept. Public Health, Boston...	Department Health Report §	♂	47	?	Somerville	Face	?	Excision; relief
1908	Dept. Public Health, Boston...	Department Health Report §	♂	39	?	Boston	Lumbar region and chest	?	?
1908	Dept. Public Health, Boston...	Department Health Report §	♂	19	?	Boston	Face	?	Incision and drainage; curettage; much relieved
1910	Dept. Public Health, Boston...	Department Health Report §	♂	14	?	Mansfield	Back	?	Incision and drainage; relieved
1910	Dept. Public Health, Boston...	Department Health Report §	♂	30	?	Worcester	Face	?	Incision (?); relieved
1910	Dept. Public Health, Boston...	Department Health Report §	♂	65	?	Roslindale	Gluteal region	?	Incision and drainage; relieved
1910	Dept. Public Health, Boston...	Department Health Report §	♂	42	?	Charlestown	Jaw	?	No operation; discharged relieved
1911	Dept. Public Health, Boston...	Department Health Report §	♂	29	?	Lynn	Face	?	Incision and curettage; relieved
1911	Dept. Public Health, Boston...	Department Health Report §	♀	23	?	Lowell	Wall of abdomen	?	Incision, drainage, curettage; died
1911	Dept. Public Health, Boston...	Department Health Report §	♂	33	?	Lawrence	Jaw	?	Incision, drainage; relieved
1912	Dept. Public Health, Boston...	Department Health Report §	♂	40	?	Quincy	Forehead	?	Incision, drainage; relieved
1913	Dept. Public Health, Boston...	Department Health Report §	♂	39	?	Boston	Lung	?	Resection of ribs; drainage; relieved
1913	Dept. Public Health, Boston...	Department Health Report §	♂	51	?	Roxbury	Lung	?	Cholecystectomy; cholelithiasis; gastric ulcer; relieved
1913	Dept. Public Health, Boston...	Department Health Report §	♂	58	?	Cambridge	Lung	?	Died
1915	Dept. Public Health, Boston...	Department Health Report §	♂	15	?	Lawrence	Face	?	Relieved
1915	Dept. Public Health, Boston...	Department Health Report §	♂	53	?	Everett	Wall of abdomen	?	Incision, curettage, drainage; relieved
1915	Dept. Public Health, Boston...	Department Health Report §	♂	26	?	Somerville	Lung	?	Incision, drainage of abscess of thigh
1916	Dept. Public Health, Boston...	Department Health Report §	♂	30	?	Chelsea	Right lung	?	Relieved
1917	Dept. Public Health, Boston...	Department Health Report §	?	?	?	Cambridge	?	?	Died
1917	Dept. Public Health, Boston...	Department Health Report §	♂	?	?	?	Wall of abdomen	?	Died
1917	Dept. Public Health, Boston...	Department Health Report §	?	?	?	Danvers	?	?	Died
1917	Dept. Public Health, Boston...	Department Health Report §	?	?	?	Westwood	?	?	Died
1917	Dept. Public Health, Boston...	Department Health Report §	♂	?	?	?	Scrotum	?	?
1918	Dept. Public Health, Boston...	Department Health Report §	♀	50	?	Attleboro	?	?	?
1919	Dept. Public Health, Boston...	Department Health Report §	♂	21	?	Boston	?	?	?

§ The accompanying facts were obtained partly from Department of Public Health records, partly from card index of patients treated in Massachusets General Hospital. The card index does not give the occupation of the patient nor the duration of symptoms. The case records of the hospital were not consulted. Actinomycosis was made reportable in Massachusetts in 1907; since that date forty-eight cases have been reported to the state department. Twenty of these patients died.

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1919	Dept. Public Health, Boston...	Department Health Report §	♀	54	?	Taunton	Ovary	?	?
1919	Dept. Public Health, Boston...	Department Health Report §	♀	28	?	Boston	Fallopian tubes	?	?
1920	Dept. Public Health, Boston...	Department Health Report §	♀	27	?	Chelsea	?	?	?
1920	Dept. Public Health, Boston...	Department Health Report §	♂	26	?	Barnstable	Neck	?	?
1920	Dept. Public Health, Boston...	Department Health Report §	♀	15	?	Boston	Pelvis	?	Died ?
1921	Dept. Public Health, Boston...	Department Health Report §	♀	15	?	?	?	?	?
1921	Dept. Public Health, Boston...	Department Health Report §	♀	14	?	Cambridge	?	?	Died
1922	Dept. Public Health, Boston...	Department Health Report §	♀	36	?	Brockton	?	?	Died
1922	Dept. Public Health, Boston...	Department Health Report §	♂	50	?	Boston	?	?	Died
1922	Dr. Guy Lane, Boston.....	Mass. Gen. Hosp. reply to personal letter, J. A. M. A.	♂	28	Teamster	Pepperall	Left cheek	7 weeks	Actinomyces demonstrated; apparently contracted the disease in Massachusetts
1922	Dr. Guy Lane, Boston.....	Mass. Gen. Hosp. reply to personal letter, J. A. M. A.	♂	50	Farmer	Norwood	Right cheek and neck	3 months	Actinomyces demonstrated; apparently contracted the disease in Massachusetts; ray fungus in pus
	Health Officer: Reports forty-eight cases, data incomplete (additional to above). State Veterinarian: Forty-six cases in cattle in five years.								
					Rhode Island				
1917	Keefe, J. W.	Am. J. Obst. **79**: 13-18, 1919.....	♀	35	Housewife	Rhode Island	Appendix and intestine	5 months	Fall and injury to spine followed by a mass in the region of the appendix
1921	O'Connell, Providence	Rhode Island Hospital.....	♂	21	Silk weaver	Rhode Island	Parotid gland	?	Laboratory diagnosis
	Health Officer: No report.								
					Connecticut				
1912	Osborne, S.	Health Officer	♀	40+	?	North Bradford	?	?	
1912	Osborne, S.	Health Officer	♀	60+	?	Killingsworth	?	?	
1914	Rappleye, W. C.	New Haven Hospital.....	♂	34	Clerk	New Britain	Cheek	3.5 months	Discharged improved
1915	Rappleye, W. C.	New Haven Hospital.....	♂	15	Schoolboy	New Haven	Appendix and cecum	6 weeks	Case also reported by Dr. E. J. Berkheiser, Chicago, and by Stanley Osborne, health officer
1917	Osborne, S.	Health Officer	♂	10+	?	Waterbury	?	?	
1917	Lane, J. E.	New Haven, personal letter Boston M. & S. J.	♀	59	Housewife	New Haven	Right jaw	?	Actinomyces found in the tissue; patient disappeared
					NORTH ATLANTIC STATES				
					New York				
1888	Butler, G. R.*	M. News **72**: 513-515, 1898.....	♂	37	Rigger	Brooklyn (Swedish)	Pulmonary	More than 2 years	Ruhräh, Case 33; struck on head by falling plank; 10 days later, pulmonary inflammation, cough, fever; actinomyces in sputum; cured with oil of eucalyptus
1889	Hartley, F.*	New York M. J. **1**: 667, 1889.....	♀	13	?	New York City	Jaw	?	Ruhräh, Case 15; previous history, bad teeth
1889	Hartley, F.*	New York M. J. **1**: 667, 1889.....	♂	22	?	New York City	Cheek	?	Ruhräh, Case 16; ulcer inside cheek extended through cheek
1889	Hartley, F.*	New York M. J. **1**: 667, 1889.....	♀	Child	?	New York City	Cheek	?	Ruhräh, Case 17; ulcer inside cheek (three cases seen in Roosevelt Dispensary)
1889	Byron, J. M.*	New York M. J. **1**: 716, 1889.....	♂	28	?	New York City (European)	Chest	6 months	Ruhräh, Case 32; "peripleuritis actinomycotica"; actinomyces in pus; returned to Europe
1889	Lange, F. E.	New York M. J. **1**: 161, 190, 1889.....	♂	25	?	New York City	Right hypogastrium	From 3 to 4 weeks	Presented, New York Surgical Society, April, 1889; actinomyces in pus; later report: operated on; poor prognosis

1889	Lange, F. E.*	Ann. Surg. **24**: 371-372, 1896	♂	43	?	New York City	Gluteal and lumbar region, left iliac fossa	?	Ruhräh, Case 49; silver nitrate and zinc; recovery
?	Hodenpyl, E.*	Med. Rec. **38**: 653-657, 1890	♀	18	?	New York City	Lung	6 months	Ruhräh, Case 30; necropsy
?	Hodenpyl, E.*	Med. Rec. **38**: 653-657, 1890	♀	13	Schoolgirl	New York City	Lung	4 months	Ruhräh, Case 31; necropsy
1894	Van Alsdale, W. W.*	Ann. Surg. **22**: 387, 1895	♀	34	?	New York City	Parotid	?	Ruhräh, Case 14; started in carious tooth; used injections of "acid cinnamyl of muriate of cocain"
1894?	Lange, F.*	N. Yorker med. Monatschr. **6**: 175, 1894	♀	50	?	New York City	Appendix	6 months	Ruhräh, Case 43; swelling opened near Poupart's ligament; actinomyces in pus
?	Kneer and Conrad*	Boston M. & S. J.	?	?	Merchant	New York City	Intestines and liver	?	Ruhräh, Case 47; necropsy
?	Moser, W.*	New York M. J. **9**: 176-177, 1894	?	?	?	Brooklyn	Liver	?	Ruhräh, Case 48; necropsy; actinomyces in miliary abscesses of liver
1894	Syms, P.*	Ann. Surg. **25**: 155-171, 1897	♀	60	?	New York City	Abdomen	4 years	Ruhräh, Case 52; actinomyces in sinus; left hospital in 2 months; 11 months later, fair condition
1895	Lange, F. E.*	Ann. Surg. **24**: 371-372, 1896	♂	21	?	New York City	Appendix	?	Ruhräh, Case 42; appendectomy; resection of fibrous tissue in ascending colon; cure
1895	Weber, L.*	Med. Rec. **60**: 814, 1901	♂	52	Bookkeeper	New York City	Jaw	18 months	Ruhräh, Case 21; chewed rye or wheat habitually; died of pneumonia
?	Lange, F. E.*	Ann. Surg. **24**: 371-372, 1896	♂	?	Physician	New York City	Perianal	?	Ruhräh, Case 50; recovery
?	Lange, F. E.*	Ann. Surg. **24**: 371-372, 1896	♂	?	Physician	New York City	Perianal	?	Ruhräh, Case 51; recurrent, after more than 1 year; condition subsequently improved
?	Lange, F. E.*	Ann. Surg. **24**: 371-372, 1896	?	?	?	New York City (?)	Jaw and temporal region	?	Ruhräh, Case 6; molar tooth abscessed; extension to temporal region
1897	Norris, C. H.; Larkin, J. H.	J. Exper. Med. **5**: 156-193, 1901	♂	23	Laborer	New York City	Lungs	7 weeks	Necropsy revealed both lungs consolidated
1898	Norris, C. H.; Larkin, J. H.	J. Exper. Med. **5**: 156-193, 1901	♂	45	Carpenter	New York City	Lungs	7 weeks	Necropsy revealed right lung consolidated
1898	Walker, J. E.*		♂	68	Drover	New York City	Neck	?	Ruhräh, Case 60; associated with cattle; died
?	Northrupp, W. P.*	Med. Rec. **35**: 802, 1889	♂	?	Butcher	New York City	Jaw	?	Ruhräh, Case 34; handled cattle with "little pearls"
1899	Walker, J. E.*		♂	?	Farmer	Hornellville	Neck	Several years	Ruhräh, Case 67
1901	Van der Veer, A., and Elting, A. W.	M. News **80**: 109-113, 1902	♂	45	Carpenter	Albany	Abdomen	3 months	Sinuses; called organisms "oospora"
?	Maass, F.	Ann. Surg. **38**: 292-299, 1903	♂	?	Dock laborer	New York City	Jaw ?	?	Chewed raw grain; actinomyces in pus
?	Maass, F.	Ann. Surg. **38**: 292-299, 1903	♂	?	Dock laborer	New York City	Jaw	?	Similar to foregoing, but actinomyces not demonstrated
1905	Parmenter, J.	Buffalo M. J. **63**: 133-137, 1907	♂	20	Dry goods clerk	Buffalo	Abdomen pericecum	.....	Appendectomy; no actinomyces demonstrated
1905	McMorrow, F.	New York M. J. **88**: 406-407, 1908	♀	?	?	Syracuse	Pelvis	3 months	Drained through vagina; actinomyces in pus; died
1906	Stanton, E. M.	Am. Med. **11**: 401-403, 1906	♂	53	Shoemaker	Albany	Kidney	2 months	Necropsy; actinomyces in abscess; old scar in transverse colon
1907	Buerger, L.	Am. J. M. Sc. **134**: 702-709, 1907	♀	16	Operator	New York City (Russian)	Dorsum, foot	4 months	Actinomycosis of the skin; rare
1910	McWilliams, C. H.	Ann. Surg. **66**: 117, 1917	?	?	?	New York City	Postanal	Several years	Excised; returned 3 years later; excised again; no return in 3 years (communication from Presbyterian Hosp.)
1913	Huber, F., and Berkowitz, S.	Am. J. Dis. Child. **8**: 113-118, 1914	♂	10	Schoolboy	New York City	Lungs	4 weeks	Struck on chest by man
1916	Towne, G. S.	Albany M. Ann. **37**: 251-257, 1917	♀	25	Office attendant	Saratoga Springs	Jaw	6 months	Treated with autogenous vaccine
1916	Dr. Steinke (presented by Dr. Rewar)	J. Cutan. Dis. **36**: 187, 1918	♀	20	Housewife	New York City	Jaw	5 months	Cured with one treatment by roentgen ray

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1916	McWilliams, C. H.	Ann. Surg. **66**: 117, 1917 (also letter from Dr. Clark, Columbia Univ.)	♂	26	Painter	New York City	Finger	6 months	Reported at New York Surgical Society, Feb. 14, 1917; cut first phalanx, third left finger on adversary's tooth; frozen section diagnosis, sarcoma; amputation; further examination showed actinomyces
1918	Robinson, M. R.	Surg., Gynec. & Obst. **29**: 569-574, 1919	♀	15	?	New York City	Ovaries and tubes	3 weeks	Complete review of literature; very rare anatomic location
1920	Russell, P. F. (also M. L. Fleming, Bellevue Hospital)	Proc. New York Path. Soc. **21**: 143, 1921	♂	44	Porter	New York City	Abdomen	1 year	Died
?	Russell, P. F. (also M. L. Fleming, Bellevue Hospital)	Proc. New York Path. Soc. **21**: 143, 1921	♂	25	.....	New York City (Panama recently)	Appendix and ileum	?	Died few hours after admission to Bellevue Hospital
1921	Haas	Discussion in Proc. New York Path. Soc. **21**: 143, 1921	♂	21	.....	New York City	Intestine	?	Dying at time of discussion
1922	Van der Veer, E. A., and Dickinson, A. M.	Med. Rec. **101**: 273-274, 1922	♂	58	Farmer	Albany	Right cheek	6 months	Kept hay, grass or straw in mouth while threshing; actinomyces in pus; cured
		PERSONAL LETTERS							
?	Abbott, A. W., Minneapolis	Personal letter	♂	40	Farmer	New York City	Left jaw	1 month	Operation and iodids; recovered
?	Luckett, W. H., New York City	Personal letter	♂	30	Bookbinder	New York City (Russian)	Neck	?	Diagnosis verified by microscope
?	Luckett, W. H., New York City	Personal letter	♀	50	Housewife	New York City	Neck	?	Lived near stable and chewed straw or hay taken from wagon-loads in passing; recovered
?	Luckett, W. H., New York City	Personal letter	♂	25	Shoe shop worker	New York City (Italian)	Neck	?	Recovered
?	Luckett, W. H., New York City	Personal letter	♂	48	Shoemaker	New York City (Greek)	Jaw, temple	?	
1913	Fleming, M. L.	Bellevue and allied hospitals	♂	29	Silkweaver	New York City	Liver	2 months	Died; laboratory confirmation of clinical diagnosis
1914	Huchincloss, A., New York City	(W. C. Clark) Columbia University, Presbyterian Hospital	♂	42	Broker	New York City	Perirectal tissue	?	Microscopic diagnosis; recovery
1916	Gibson, C. L.	Society of New York Hospital	♂	40	?	?	Colon and general	6 weeks	Appendectomy for acute appendicitis about 2 months before; died
1918	Boas, E. P.	Montefiore Hospital	♂	24	Grocer clerk and peddler	New York City (Russian)	Lung, chest wall, brain, heel, knee	20 months	Actinomyces in sputum and in sections from sinus (patient also visited Mt. Sinai Hospital)
1919	Harrig, New York City	Data furnished by T. Ordway, Union University	♂	65	Brewery worker	Albany	Left pleural cavity and thoracic wall	6 weeks	Healed tuberculous lesion of left lung; died; diagnosis made at necropsy
1919	Elting, New York City	T. Ordway	♀	44	?	Albany	Breast and axillary glands	?	Histologic diagnosis, granules in pus
1920	Beilby, New York City	T. Ordway	♂	58	Farmer	Spencertown	Cervical and facial	7 months	Not verified by laboratory
1920	Oliver, H. I., Syracuse, N. Y.	.....	♀	32	Farmer's wife	Syracuse	Jaw	?	Had habit of chewing straws
1920	Gibson, C. L.	Soc. New York Hospital	♂	Old	?	?	Abdominal wall	2 years	Died
1921	Lawler, C. A., Salamanca	Dept. Hosp. and Disp., Buffalo (reported by W. S. Goodale)	♂	16	Hide trimmer	Salamanca	Left side of face	1 month	While trimming raw hide scratched his face; few days later noticed lump; actinomyces found in smear by resident, not verified by Board of Health
1921	Binford, Throne	Skin and Cancer Hospital	♀	21	Domestic	New York City	Neck and jaw	1 year	Worked formerly in fur shop; struck on jaw by man's fist; jaw immediately swollen; lesion developed after admission to hospital, showing actinomyces; enormous doses of iodids given
1921	Bacon, C. B.	City Hospital, Welfare Island	♀	21	Housework	New York City	Jaw	1 year	A life resident of New York City

1922	Gibson, C. L.	Soc. of New York Hospital	♂	50	?	?	Submaxillary gland	2 weeks	In excellent condition
1922	Gibson, C. L.	Soc. of New York Hospital	♂	28	?	?	Abdominal wall	?	Appendectomy 6 months previously for acute appendicitis
1922	Stanton, E. M., Schenectady	Personal communication	♂	14	?	Schenectady	Abdomen	?	Well, January, 1923
1922	Mathews, F. S.	Reported by E. F. Clover, St. Luke's Hospital	♂	16	Office boy	New Brighton	Wall of right chest	10 weeks	Actinomyces in pus; during preceding summer was in small town in central New York for 2 weeks; no immediate contact with cattle
1922	Elting, New York City	T. Ordway	♂	14	Schoolboy	Schenectady	Wall of abdomen	2 months	Fond of animals, with them a good deal; actinomyces in pus
1922	Clark, W. C.	Columbia University	♀	38	Housewife	New York City	Sternal, mammary, intercapsular, lateral, abdominal, lungs	From 5 to 6 weeks	Lesions discovered 7 weeks following operation
1922	Clark, W. C.	Columbia University	♂	60	Danish consul	Shanghai, China	Lumbar region	8 months	Actinomyces in tissue
1922	Clark, W. C.	Columbia University	♀	23	Nurse	Burlington, Vt.	(Under Vermont)		
					Pennsylvania				
1889	Bodamer, A.*	M. News **54**: 230-232, 1889	♂	32	Miner	Luzern Co.	Jaw	?	Ruhräh, Case 21; in 1877, struck on head by prop; in 1882, noticed swelling of right jaw; entered hospital for removal of tumor, in 1884; more injuries in 1888; in 1889, actinomyces found
?	Northrup, W. P.*	Med. Rec. **35**: 302, 1899	♂	?	Schoolboy	Pennsylvania	Mediastinum	?	Ruhräh, Case 41
?	DaCosta*	Progr. Med. **1**: 23, 1899	♂	?	Mattress stuffer	Philadelphia	Head and neck	?	Ruhräh, Case 63; actinomyces found by Dr. Kyle; potassium iodid given; improvement
?	DaCosta*	Progr. Med. **1**: 23, 1899	♂	?	Stableman	Philadelphia	Head and neck	?	Ruhräh, Case 64 (Dr. Hearn's case); frequently chewed straws
?	DaCosta*	Progr. Med. **1**: 23, 1899	♂	?	Physician	Philadelphia	Arms	?	Ruhräh, Case 65 (Dr. Keen's case); ulceration into axillary artery; nearly fatal hemorrhage; Dr. Kyle demonstrated actinomyces in granuloma; recovered
1900	Musser, J. H.; Pearce, A. M.; Gwynn, N.	Tr. A. Am. Phys. **16**: 208-216, 1901	♂	37	Business man	Philadelphia	Lungs	6 weeks	"Streptothrix" in sputum; died
1900	Musser, J. H.; Pearce, A. M.; Gwynn, N.	Tr. A. Am. Phys. **16**: 208-216, 1901	♂	24	?	Philadelphia	Brain	1 week	"Streptothrix" in brain; died
1900	Stengel, A.	Med. Rec. **77**: 954, 1910	♀	15	?	Pennsylvania	Jaw	3 months	Injury by dental instruments; potassium iodid given locally and internally; cured
1901	Ewing, W. G.	Bull. Johns Hopkins Hosp. **13**: 261-268, 1902	♂	26	Farmer	Pennsylvania	?	6 months	Actinomyces in pus; potassium iodid given; operation
1906	Young, J. K.	Am. J. Orthop. Surg. **6**: 252-255, 1909	♂	39	Lawyer	Pennsylvania	Ribs and vertebra	About 1 year	Necropsy confirmed diagnosis
1906	Wood, A. C., Eshner, A. A.	Med. Rec. **77**: 947-954, 1910	♂	36	Fur worker	Philadelphia (Russian)	Lung	?	Primary in lung; actinomyces in sputum (at this time "Streptothrix" considered best generic name for group)
?	Frazer, C. H.	Tr. Philadelphia Acad. Surg. **14**: 72, 1912	?	72	?	Philadelphia	Abdomen	?	Reported in discussion of report of New Jersey case by DaCosta (other reports by Dr. Asherst and Dr. J. K. Young)
1920	Bryant, C. K.	Dental Cosmos **64**: 198-204, 1922	♂	60	Farmer	Philadelphia	Jaw	3 years	Extraction of teeth gave relief for a time; actinomyces found in pus

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
					PERSONAL LETTERS				
?	Ivy, R. H., Philadelphia	Polyclinic Hospital	♀	28	Housewife	Delaware	(under Delaware)		
1899	Gifford, U. G., Kennett Sq.	Personal letter; suggested by S. Solis Cohen	♂	32	Farmer	West Grove	Liver	?	Injured in fall, developed abscess of liver; actinomyces found in pus from liver; died of pulmonary tuberculosis about 6 years ago
1910	Forbush, C. L., Philadelphia	Bureau of Health, Philadelphia	♂	23	Inspector of gas meters	?	?	?	?
1915	Forbush, C. L., Philadelphia	Bureau of Health, Philadelphia	?	?	?	?	.....	.....	No data except "source not determined"
1917	Batt, W. R., Harrisburg	State Registrar	♂	?	?	Montrose	.....	.....	Incomplete records
1918	Batt, W. R., Harrisburg	State Registrar	♂	?	?	Pittsburgh	.....	.....	Incomplete records
1918	Batt, W. R., Harrisburg	State Registrar	♀	?	?	Reading	.....	.....	Incomplete records
1921	Pendergraas, E. P., Philadelphia	University Hospital in reply to J. A. M. A. letter	♂	60	Laborer	?	Jaw	1 year	Worked around cattle; cultures grew actinomyces; operation for ankylosis of jaw 2 years before
1922	Bowman, G., Irwin	Mercy Hospital (E. P. Buchman, Pittsburgh)	♂	?	?	? (Italian)	Jaw	Short duration	Wassermann ++; no actinomyces demonstrated, but lesion looked very much like actinomycosis (?)
					New Jersey				
1902	Wallhouser, H. J. F.	J. Cutan. Dis. **22**: 77-79, 1904	♂	28	Teamster	Newark	Jaw	4 months	
?	DaCosta, J. C.	Tr. Philadelphia Acad. Surg. **14**: 72, 1912	♂	62	?	New Jersey	Jaw	?	Two carious teeth in upper left jaw
1915	Newman, E. D.	J. Cutan. Dis. **34**: 290-295, 1916	♂	28	Farmer	South Orange	Jaw, lungs, right arm, wall of chest	?	Jaw infected first, subsequent systemic infection; Dr. H. Zinsser obtained cultures of actinomyces from right arm
					PERSONAL LETTERS				
1922	H. H.	Personal communication from patient (name furnished by Dr. H. J. Achard, Chicago)	♂	43	Engineer	New Jersey, also New York	Left lung	2 years	Pleurisy following operation for duodenal ulcer; extensive travel abroad on business and for treatment; culture "Streptothrix" was obtained at Saranac Lake; animal inoculations were negative; potassium iodid, sodium iodid, aspiration, supersan oil
					Delaware				
?	Ivy, R. H., Philadelphia	Polyclinic Hospital, Philadelphia	♀	28	Housewife	Wilmington	Jaw	3 months	Actinomyces in pus; cultures failed; serologic tests (Dr. Kolmer) were negative; improved
					Maryland				
1895	Latimer, T. S.*, Welch, W. H.	Internat Clin **3**: 152-154, 1896; Tr. A. Am. Phys. **11**: 328-339, 1896	♂	21	Laborer	Baltimore	Appendix, liver and colon	3 months	Ruhräh, Case 44; necropsy; patient also had leukemia
1896	Tiffany, S. M.*	.....	♂	36	?	Maryland	Cecum	3 years	Ruhräh, Case 72; died of malnutrition
1896	Flexner, S.	J. Exper. Med. **3**: 435-450, 1898; also Bull. Johns Hopkins Hosp. **8**: 128, 1897	♂	70	? (Negro)	Baltimore	Lungs	?	Pseudotuberculosis hominis streptothrica; not in Ruhräh's cases
1897	Tiffany, S. M.*	.....	♂	36	Farmer	Frederick Co.	Cheek	2.5 months	Ruhräh, Case 5
?	Tiffany, S. M.*	.....	♂	32	Farmer	Frederick Co.	Jaw	?	Ruhräh, Case 7; curetted, phenol (carbolic acid); cured
1897	Blake*	.....	♀	19	Housewife	Maryland	Lungs	?	Ruhräh, Case 35; actinomyces in sputum; hemorrhages (unusual) seen in consultation by Ruhräh
1898	Rosenthall, M.*	.....	♂	17	?	Baltimore	Chest	5 months	Ruhräh, Case 36; abscess drained twice; died after second operation
1899	Erving, W. G.	Bull. Johns Hopkins Hosp. **13**: 261-268, 1902	♂	31	Fireman	Maryland	Abdominal wall	1 year	Surgery and potassium iodid; improved

?	Stokes, W. R.	Am. J. M. Sc. **128**: 861-875, 1904	♂	1 mo.	?	Baltimore	Lungs	?	Died; marasmus; pure culture showed actinomyces from abscess in lower lobe of left lung
?	Stokes, W. R.	Am. J. M. Sc. **128**: 861-875, 1904	♂	60	?	Baltimore	Bladder	?	Cultures: actinomyces vesicae brilliant orange; distinguished from actinomyces asteroides by fact that it liquefies gelatin, casein and blood serum
1919	Pels, I. R.	J. Cutan. Dis. **37**: 740, 1919	♂	72	Farmer	Maryland	Right hand	18 months	Never chewed grains; injured hand cranking gasoline engine; put on tobacco from his mouth for several hours; prompt healing followed; actinomyces in old laceration
1919	Cecil, H. L., and Hill, J. H.	J. A. M. A. **78**: 575-578, 1922	♂	35	Electric welder	Maryland	Kidney	1 year	Actinomyces bovis grown from right kidney; *pH* 5 agar plates; potassium iodid treatment
					Washington, D. C.				
1901	Butterfield. E. E.	J. Infect. Dis. **2**: 421-430, 1905	♂	19	?	Washington	Lungs	2 years	Acid-fast "Streptothrix"; necropsy
					SOUTH ATLANTIC STATES				
					Virginia				
1896	Gardner, W. S.*		♀	30	Housewife	Waterford	Pelvis	6 months	Ruhräh, Case 30; a mass in the region of right ovary; died; pathologic diagnosis revealed actinomycosis
1901	Erving, W. G.	Bull. Johns Hopkins Hosp. **13**: 261-268, 1902	♂	17	Rivet cleaner	Virginia	Jaw	1 year	Actinomyces in pus; potassium iodid given
1901	Erving, W. G.	Bull. Johns Hopkins Hosp. **13**: 261-268, 1902	♂	43	Farmer	Virginia	Right abdomen	10 months	Actinomyces in pus; surgery; iodoform gauze; died
					PERSONAL LETTERS				
1908		Univ. of Va. Hosp., Charlottesville	♂	38	Laborer	Luray	Right temporo-maxillary region	3 months	Slight swelling two months previously; discharging sinus; smears from pus showed ray fungus; curetting; mercuric chlorid and potassium iodid given; partial ankylosis
1908		Univ. of Va. Hosp., Charlottesville	♂	50	Farmer	Greenville	Left jaw	5 to 6 weeks	Actinomyces in pus; partial ankylosis; improved
1912		Univ. of Va. Hosp., Charlottesville	♂	60	Farmer	Williamsville	Right upper jaw	7 months	Soft swelling; actinomyces present
		Univ. of Va. Hosp., Charlottesville	♀	18	Schoolgirl	Amherst	Left lower jaw	3 months	Actinomyces in pus; incised, curetted, packed; discharged in 24 hours
1915	Urbach, H.	Med. College of Va., Richmond	♂	48	?	Richmond	?	?	Colored; coughed for 9 years and worse last 2 months; potassium iodid given
1916		Univ of Va. Hosp., Charlottesville	♀	35	Janitress (colored)	Staunton	Left jaw	5 months+	Actinomyces; ankylosis; potassium iodid was given; improved
1920		Univ. of Va. Hosp., Charlottesville	♀	34	Housewife	Warrenton	Right pelvis	2 years, 3 months	Swelling over crest of ilium; actinomyces in pus; arsphenamin and potassium iodid given; improved
					North Carolina				
1900	Erving, W. G.	Bull. Johns Hopkins Hosp. **13**: 261-268, 1902 (from Dr. J. M. Finney)	♂	46	Farmer	N. Carolina	Abdomen	Several months	Actinomyces in pus; potassium iodid given; died
1919	Griffith, E. W.	Surg., Gynec. & Obst. **33**: 548, 1921	♂	31	Railroad fireman	N. Carolina	Cecum	4 or 5 months	Operated on; tissue sent Dr. Winternitz of Yale; probably actinomycosis
1920	Griffith, E. W.	Surg., Gynec. & Obst. **33**: 548, 1921	♀	38	Housewife	N. Carolina	Jaw, cecum, pelvis	7 or 8 months	Owned cow with lump-jaw several years before; abscess of jaw first; operated on; appendix and cecum bound down by adhesions; pelvic abscess

South Carolina

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1922	Corbett, H. W., Anderson.....	Anderson Co. Hospital.....	♂	24	Farmer	Westminster	Lungs	1.5 years	Diagnosed chronic pulmonary tuberculosis; sputum negative for tuberculosis; November, 1922, sputum showed actinomyces

Georgia

MAYO CLINIC CASE

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1918	1	♂	63	Farmer	Oakland	Alabama	Neck	1 month	Had several bad teeth; mass on left side of neck had grown rapidly; pathologist's report, actinomycosis; patient also seen by Dr. Thrash, Atlanta, Ga.

Florida

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1921	Spelman, J. D., New Orleans...	Touro Infirmary, New Orleans.....	♀	26	Housewife	Florida	Pelvis	2 years	

State Veterinarian of Florida stated that, of the 87,151 cattle coming under inspection, only forty showed actinomycosis, or 0.0004 per cent. He also stated that often slight lesions were found in the tongues of animals having no evidence anywhere else, but that in the cattle mentioned, the tongues were almost entirely free from such lesions.

EAST CENTRAL STATES

Michigan

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
?	Darling, C. G.	Physician & Surg. **25**: 315-318, 1903..	♂	41	Farmer	Michigan	Abdomen, right side	?	Report to Clinical Society of University of Michigan; discussed by Warthin
?	Maass, F.	Ann. Surg. **38**: 292-299, 1903.....	♂	?	Farmer	Detroit	Lungs	?	From grains ?
?	Maass, F.	Ann. Surg., **38**: 292-299, 1903.....	♀	?	?	Detroit	Abdomen	?	?
?	Maass, F.	Ann. Surg., **38**: 292-299, 1903.....	♀	?	?	Detroit	Abdomen	?	?
1907	McJunkin, F. A.	Physician & Surg. **29**: 213-216, 1907..	?	?	?	Michigan	?	?	Dr. Canfield's case; not located definitely
1907	McJunkin, F. A.	Physician & Surg. **29**: 213-216, 1907..	?	?	?	Michigan	Spine	?	Diagnosed at necropsy
1907	McJunkin, F. A.	Physician & Surg. **29**: 213-216, 1907..	♀	17	?	Michigan	Jaw	.....	Dr. Canfield's clinic

PERSONAL LETTERS

?	University Hospital, Ann Arbor	Univ. Hosp., reply to letter.....	♂	51	Farmer	Onaway	Right side of face	4 weeks	Wassermann reaction negative
?	University Hospital, Ann Arbor	Univ. Hosp., reply to letter.....	♀	29	Housewife	Pontiac	Left cheek	2 months	Wassermann reaction negative
?	University Hospital, Ann Arbor	Univ. Hosp., reply to letter.....	♂	56	Farmer	Mt. Pleasant	Lower lip	3 years	Wassermann reaction negative
?	University Hospital, Ann Arbor	Univ. Hosp., reply to letter.....	♂	44	Engineer	Battle Creek	Left jaw	3 months	Wassermann reaction negative
?	University Hospital, Ann Arbor	Univ. Hosp., reply to letter.....	♂	30	Farmer	Goodrich	Right thigh	1 year	Wassermann reaction negative
?	University Hospital, Ann Arbor	Univ. Hosp., reply to letter.....	♂	10	Schoolboy	Monroe	Right jaw	1 year	Wassermann reaction negative; died from subphrenic abscess
1913	Dr. Chislett, Chicago.....	Reply to letter, Hahnemann Hosp...	♂	?	Student	Lansing	Right lower jaw	2 months	Trouble first attributed to erupting wisdom tooth; actinomyces in pus; permanent recovery
1920	Grand Rapids	Reply to letter, Blodgett Memorial Hospital	♂	60	Farmer	Alma	Left cheek	.....	Mayo Clinic case also
1921	Haughey, W., Battle Creek....	Reply to letter in J. Mich. M. S.	♂	25	Manager music store	Michigan	Tongue and temple	8 months	While hunting cut tongue on blade of grass; abscess formed; swelling over right temporal area; necrosis of bone, immense amount of pus; Dr. Novy demonstrated actinomyces; died; no necropsy
1922	Morrill, D. M., Ann Arbor.....	Report from Dept. Health, Lansing	♂	22	Brakeman	Michigan	Abdomen	2 months	Appendectomy 1 year before; granules in pus; died
1923	Smith, M. E., Muskegon.....	Report from Dept. Health, Lansing	♂	10	?	?	?	?	?

1922	Smith, M. E., Muskegon	Report from Dept. Health, Lansing	♂	10	?	?	?	?	?	Appendectomy 1 year before; granules in pus; died

1922	Squier, T. L., Battle Creek	Report from Dept. Health, Lansing	♂	28	Yardman	Battle Creek	Jaw	1 month	Had habit of whittling splinters of wood from box car in yards and using for toothpicks; treated by Dr. Stone

*(Also, under recent communication from Dr. Warthin).

MAYO CLINIC CASES

1920	Case 2		♂	60	Farmer	Alma	Left cheek	3 months	Reported from Blodgett Memorial Hospital; swelling incised; actinomyces in pus
1921	Case 3		♂	47	Minister	Holland	Testis	10 months	Pathologic diagnosis after orchidectomy; previous diagnosis elsewhere; tuberculosis on finding acid-fast bacilli

* Summary of Dr. Warthin's Cases

	Cases		Cases
Actinomycosis of tongue	3	Actinomycosis of kidney	12 or more
Actinomycosis of human jaw	3	Primary actinomycosis of uterus	1
Actinomycosis of cervical lymph nodes	6 or 8	Primary actinomycosis of vagina	1
True actinomycosis of tonsil	2	Primary actinomycosis of liver	3
Primary actinomycosis of vertebrae, actinomycotic Pott's disease	2	Primary actinomycosis of rectal fistula	2
Primary actinomycosis of lung and pleura	5 or 7	Primary actinomycosis of brain	1
Primary actinomycosis of abdominal wall, all in young men hostlers	5	Primary actinomycosis of foot in the form of Madura foot	1
Primary actinomycosis of appendix	12 or 15	Primary actinomycosis of foot in the form of osteomyelitis	1

Ohio

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1896	Hoover, C. A.*		♂	43	Laborer	Cleveland	Jaw	26 months	Ruhräh, Case 8; died; necropsy confirmed diagnosis
1897	Ohlmacher, A. P.	Cleveland M. J. **1**: 29, 1902	♀	25	Inmate epileptic hospital	Ohio	Right jaw, neck, lungs	3 years+	Acid alcohol-fast branching organism in sputum; improved after going home; classed as atypical member "ray-fungus" group
1899	Hoover, C. A.*		♂	65	Carpenter	Cleveland	Lung	2 years	Ruhräh, Case 37; treated a horse with lump jaw 3 months before; swelling under right clavicle; died
?	Park, R.*	Buffalo M. J., pp. 326-337, 1902	♂	30	Clerk in stockyards	Buffalo	Liver	Several months	Ruhräh, Case 39; cough; abscess; drained; actinomyces present; died from shock
1900	Oliver, J. C.	Ann. Surg. **32**: 668-672, 1900	♂	49	Jeweler	Cincinnati	Jaw	?	Had nothing to do with cattle; used wax-stick for setting diamonds, which he held in his mouth
1903	Howard, W. T., Jr.	J. M. Res. **9**: 301-323, 1903	♂	52	Hospital orderly	Cleveland	Central nervous system	?	Unidentified actinomyces
1903	Heidingsfeld, M.	Am. J. Dermat. **12**: 49, 1903; also, Lancet-Clinic **1**: 328, 1903	♂	62	Farmer	Miami	Jaw		
1909	Jones, H.	Med. Rec. **78**: 363, 1910	♂	?	?	Circleville	Cheek	3.5 months	Ulcerated tooth; copper sulphate given locally; cured
1909	Jones, H.	Med. Rec. **78**: 363, 1910	♀	?	?	Circleville	Jaw, clavicle and rib	?	Started in carious tooth

PERSONAL LETTERS

1915		Lakeside Hosp., Cleveland, also Dr. H. Hart	♂	40	Shoemaker	Cleveland	Left anterior thoracic wall	1.5 years	Surgery; had one transfusion; also several injections of typhoid vaccine; died
1915	Kramer	Cincinnati General Hospital	♀	25	Housewife	Cincinnati, native of Russia	Cerebellar region	?	Had been stringing corn; had habit of chewing corn; died; necropsy
1919	?	Cincinnati General Hospital	♂	40	Merchant and mechanic	Cincinnati	Abdomen	3 years	Died
1919	?	Lakeside Hospital, Cleveland	♂	46	Night watchman	Cleveland (Syrian)	Jaw	3 years	Pathologic report, probable actinomycosis; ray fungi not found; arsphenamin; improved
1922	Beatty, B. W.	St. Elizabeth's Hospital, Dayton	♂	28	Farmer	Indiana	.....	.....	Under Indiana

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1920	4	♂	32	Engineer	Dayton	Ohio	Lungs	7 months	Had influenza, January, 1920, followed by pneumonia; expectorated large amounts of pus; slow recovery; actinomyces in sputum
1921	5	♂	28	Farmer	Lewisburg	Indiana	Cervical region	3 years	Lumps in neck for 3 years; one year before, had pain in jaw; teeth were extracted; abscess behind right ear drained; actinomyces in pus; died
1922	6	♀	22	Farmer's widow	Payne	Ohio	Left mandible	1 year	Always lived on farm; ankylosis of jaw; drainage; actinomyces in pus; radium; potassium iodid
1922	7	♂	48	Farmer	Belmore	Ohio	Right side of neck	8 weeks	Actinomyces in pus; no lump-jaw in cattle; did not chew grass, hay or weeds; very extensive; poor prognosis

West Virginia

PUBLISHED CASE

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1901	Erving, W. G.	Bull. Johns Hopkins Hosp., **13**: 261-268, 1902	♀	43	Manager telephone office	West Virginia	Right abdomen	10 months	Actinomyces in pus; surgery; potassium iodid not tolerated; improved slowly

PERSONAL LETTER

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
?	Henshaw, Charleston	Letter (also treated by J. C. Bloodgood, Baltimore)	♀	?	?	Martinsburg	Liver	.....	Operation successful

Indiana

PUBLISHED CASE

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1904	Bevan, A. D., Post, W. E.	Chicago M. Rec. **27**: 695-708, 1905....	♂	40	Carpenter	Indiana	Chest and lung	?	Resected sixth rib; actinomyces in sputum; huge doses of potassium iodid were given, with some improvement

PERSONAL LETTERS

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1921	Shanklin, V. A., Terre Haute..	Health officer	♀	64	Housewife	Eddington	?	?	Died from actinomycosis (information from death certificate)
?	Pfaff, J. A., Indianapolis.....	Answer to letter, J. A. M. A.	♂	72	Accountant	Indianapolis	Jaw	9 months	Actinomyces in pus; potassium iodid given; died 5 years later from chronic interstitial nephritis
1922	Downs, W. E., Evansville.....	Answer to letter in Dental Cosmos...	♂	30	Laborer	Evansville	Lower right jaw	3 or 4 months	Considerable ankylosis; teeth in bad condition; actinomyces present in microscopic examination; injected 7 per cent. potassium permanganate, irrigated with 1:1,000 potassium permanganate, packed loosely with iodin saturated gauze; month later, mouth well healed and color good

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1919	8	♂	49	Farmer	Valparaiso	Illinois	Neck	3 months	Ate wheat kernels while cutting wheat; few days later, noticed swelling in throat, painless at first; later ruptured and actinomyces found in pus
1920	9	♂	27	Clerk	Richmond	Ohio	Neck	8 months	Eight months before, noticed a swelling in jaws following dentistry; abscess of the right temporal region; actinomyces in pus
1920	10	♀	21	.....	Terre Haute	Indiana	Right side of neck	3 months	Sinus following tonsillectomy; actinomyces in pus
1920	11	♂	27	Tile mill	Huntington	Indiana	Appendiceal abscess	5 months	Abscess opened; sinus; tissue from abdomen showed actinomycosis
1920	12	♂	46	Meat cutter	Indianapolis	United States	Tongue	10 days	Lump at tip of tongue; pathologic report revealed actinomycosis
1921	13	♂	22	Leather cutter	Richmond	Indiana	Appendix and sigmoid	1.5 years	Pain in right lower quadrant; abdomen drained; peritonitis; sinus; actinomyces in pus
1922	14	♂	58	Dealer in real estate	North Vernon	Indiana	Abdomen after appendectomy	2 years	Discharging sinus, also diabetes mellitus

Kentucky

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1900	Bullitt, J. B.	Ann. Surg. **31**: 600-608, 1900	♀	25	Housewife	Louisville	Lungs	?	Actinomyces in sputum; necropsy: Dr. Flexner reported pathologic condition in lungs due to "streptothrix actinomyces"

CENTRAL STATES (MISSISSIPPI VALLEY)

Illinois

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1884	Murphy, J. B.*	New York M. J. **41**: 17-19, 1885	♀	28	Servant	Chicago	Left lower jaw	1 month	Ruhräh, Case 26; First case reported in America
1884	Murphy, J. B.*	New York M. J. **41**: 17-19, 1885	♂	18	?	Chicago	Right lower jaw	?	Ruhräh, Case 9; had trouble with teeth year before while in Ireland
?	Murphy, J. B.*	New York M. J. **41**: 17-19, 1885	?	?	?	Chicago	Appendix and intestine	?	Ruhräh, Case 14; diseased tissue was removed; recovered
1886	Schirmer, A.*	Clin. M. J. & Exam. **53**: 351, 1886	♂	25	Laborer	Chicago	Head, neck and lungs	7 years ?	Ruhräh, Case 58; wounded cheek while chopping wood causing immediate swelling; actinomyces found seven years later, also found in sputum; death
1886	Ochsner, A. J.*	J. A. M. A. **7**: 608-610, 1886	♂	56	Stock raiser	Chicago	Antrum and lung	4 years	Ruhräh, Case 2; owned cattle having lump-jaw; actinomyces found in sputum; death; later report in M. News
1888	Brown, E. L.*	Chicago Med. Rec. **7**: 251-253, 1894	♂	48	Machinist	Chicago (Austrian)	Jaw	1 month	Ruhräh, Case 20; ate bologna sausage for lunch
?	Van Hook, W.*	Note to Ruhräh	♂	?	Laundryman	Chicago	Jaw	?	Ruhräh, Case 11; curetted; cured
?	Van Hook, W.*	Note to Ruhräh	♂	55	Farmer	Chicago	Jaw	More than 1 year	Ruhräh, Case 22; had several operations; had alcoholic habit; death resulted from basal meningitis
1890	Ochsner, A. J.*	M. News **58**: 97-98, 1891	♂	53	Farmer	Illinois?	Jaw	8 months	Ruhräh, Case 1; had treated a horse supposed to have lump-jaw
1891	Murphy, J. B.*	N. Am. Practitioner **3**: 593-607, 1891	♀	55	Housewife	Chicago	Lower jaw	?	Ruhräh, Case 19; tooth extracted; actinomyces found in pus; recovered
1891	Murphy, J. B.*	N. Am. Practitioner **3**: 593-607, 1891	♂	?	?	Chicago	Abdomen	5 weeks	Ruhräh, Case 4; actinomyces found in pus; death
?	Murphy, J. B.*	Notes to Ruhräh by Dr. Witwer	♂	27	Servant	Chicago	Lower left jaw	?	Ruhräh, Case 10; actinomyces ("actinocladothrix") found in pus
?	Ferguson, A. H.*		♂	?	?	Chicago	Omentum and intestine	?	Ruhräh, Case 60; operated on for hernia; sinus followed; death
1896	McArthur, L. L.*		♀	22	Clerk	Chicago	Breast	15 months	Ruhräh, Case 61; death
1898	Fütterer, G.	New York M. J. **74**: 337-341, 1901	♂	39	Commercial traveler	Chicago	Abdomen	7 years	Actinomyces found in scrapings from sinus; necropsy: actinomycotic foci in heart
1899	Lee, W.*	Data furnished Ruhräh by J. B. Murphy	?	?	?	Chicago	Right iliac fossa	?	Ruhräh, Case 46
1900	Morris, C. C.	St. Louis M. & S. J., 1901	♂	30	Minister	Illinois	Jaw	8 months	Now lives at Wood River, Ill., in perfect health after 23 years; personal communication from patient to author
1902	Bevan, A. D., and Post, W. E.	Chicago M. Rec. **27**: 675-708, 1905	♂	31	Farmer	Illinois	Neck	2 months	Drainage; potassium iodid given
1903?	Harsha, W. M.	Illinois M. J. **5**: 598, 1903	♂	50	?	Illinois	Jaw	?	Reported at Chicago Surgical Society
1903	Hartmann, W. M. (L. L. MacArthur's case)	Tr. N. Chicago Path. Soc. **6**: 157-161, 1903	♀	26	?	Chicago	General	4 months	Necropsy revealed multiple abscesses and miliary actinomycosis of lung

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1903	Bevan, A. D., and Post, W. E.	Chicago M. Rec. **27**: 695-708, 1905....	♀	19	Living at home	Illinois	Pelvis	Several weeks	Drained through vagina; probably appendiceal abscess
1904	Bevan, A. D., and Post, W. E.	Chicago M. Rec. **27**: 695-708, 1905....	♂	11	Schoolboy	Illinois	Appendix	?	Abscess drained; potassium iodid given
1904	Bevan, A. D., and Post, W. E.	Chicago M. Rec. **27**: 695-708, 1905....	♂	35	Captain on lake vessel	Chicago?	Appendix	More than 2 years	
?	Matlock, J. A.	Interstate M. J. **12**: 453-457, 1905....	♀	32	Farmer's wife	Illinois	Lungs and chest wall	3 months	Primary in lung with sinus through wall of chest
?	Hessert, W.	Illinois M. J. **7**: 289, 1905.....	♀	15	.....	Illinois	Jaw	?	Reported from Chicago Surgical Society; caries of tooth
1905	Zeisler, J.	J. Cutan. Dis. **24**: 510-512, 1906.....	♀	24	?	Illinois	Jaw	2½ months	Had habit of chewing grass while playing golf; particles of grain lodged under tongue
1913	Baugher, A. H.; also, Davis, D. J., and Garcia, O.	Tr. Chicago Path. Soc. **10**: 78-82, 1916 Arch. Dermat. & Syph. **7**: 1-13, 1923	♀	55	Housewife	Chicago	Subcutaneous multiple lesions	1 week	Frequently had been struck with thorn of rose trees and of cactus plants; acid-fast "streptothrix" repeatedly found in smears and cultures; experimental work done by Davis and Garcia with strain most interesting; pathogenic to rabbits, rats, guinea-pigs and mice
1914	Davis, D. J.	Arch. Int. Med. **14**: 1-7, 1914.....	♂	64	Teamster	Chicago	Lungs	Several years?	Had chronic cough; in hospital four weeks; acid-fast "streptothrix" (Nocardia) in sputum
1916	Zeisler, J.	J. Cutan. Dis. **35**: 274, 1917.....	♀	26	?	Chicago	Chin and neck	2 months	Much discussion over this case at Chicago Dermatological Society; improved with potassium iodid
1916	Ochsner, A. J.	S. Clin. Chicago **1**: 1203-1211, 1917...	♂	44	Laborer	Chicago	Descending colon	6 months	Became sick while working in a camp; bloody, fecal discharge from tumor on left groin; actinomyces found in stool; ileocolostomy; potassium iodid given
1916	Ochsner, A. J.	S. Clin. Chicago **1**: 1203-1211, 1917....	?	?	?	Chicago	Colon and liver	?	Necropsy; mentioned only in discussion of preceding case
1916	Ochsner, A. J.	S. Clin. Chicago **1**: 1203-1211, 1917....	?	?	?	Chicago	Jaw, neck and larynx	?	Recovered; mentioned in foregoing discussion
		PERSONAL LETTERS							
?	Clark	Hahnemann Hospital, Chicago (reported by V. R. Hoener)	♂	?	Stockyard teamster	Chicago	Right lower jaw	?	Hauled dust and dirt from road in stockyards, constantly subject to clouds of dust; actinomyces found in pus
?	Clark	Hahnemann Hospital, Chicago (reported by V. R. Hoener)	♀	27	Nurse	Chicago	Jaw	?	Nursed patient in room next to one in which there was a case of actinomycosis; had abscessed tooth; nodule on left cheek; actinomyces in pus
1908	Bufe, E. K. (librarian).....	Michael Reese Hospital.....	♂	?	?	Chicago	Liver and lungs	?	Drainage of subphrenic abscess; death; necropsy: generalized actinomycosis
1910	Kahlke, C. E.	Hahnemann Hospital, Chicago (reported by V. R. Hoener)	♀	37	Housewife	Chicago	Abdomen	8 months	Appendiceal abscess; ray fungus found in pus, confirmed by Strauss and Jobling at Michael Reese Hospital; huge doses of potassium iodid given; death
1912	Kahlke, C. E.	Hahnemann Hospital, Chicago.....	♀	57	?	Chicago	Gallbladder	?	Gallbladder drained, 12 or 15 stones removed; peritoneum studded with hard nodules; sinus discharged showed actinomyces; death

1913	Chislett	Hahnemann Hospital (under Michigan cases)				.....	.....	.....	Agricultural student, Lansing, Mich.
1916	Clark	Hahnemann Hospital, Chicago (reported by V. R. Hoener)	♂	7	Schoolboy	Wheaton	Jaw	7 months	History of injury to jaw and cheek by stalk of ragweed when patient fell while running through freshly cut corn field
1920	Bufe, E. K. (librarian).....	Michael Reese Hospital.....	♀	23	Housewife	Chicago	Jaw	2 months	Incision and drainage; discharged in excellent condition
1920	Henderson	Hahnemann Hospital, Chicago (reported by V. R. Hoener)	♀	38	Housewife	Chicago	Pelvis	5 months	Spontaneous discharge in right groin, came on after confinement; actinomyces found in discharge; large doses of potassium iodid given; died in Detroit
1922	Dunham, L. H.	Lake View Hospital, Danville.....	♂	54	Farm tenant	Danville	Left lower jaw	5 months	Typical granules; poor teeth; had habit of picking teeth with straw and weeds; cultures positive
1922	Meyer, K. A.	Cook County Hospital, Chicago, reply to letter	♂	9	Schoolboy	Chicago	Right side of thorax, pleural cavity and lung	6 months	Actinomyes found in pus; year before while in country had chewed straws after meals; had had several ribs fractured by automobile 5 years before; death; necropsy: actinomyces of both lungs, liver, dorsal vertebrae, periaortic and mesenteric lymph glands
1922	Bundesen	Department of Health, Chicago (reported by J. J. McShane)	♂	10	Schoolboy	Chicago	Lower thoracic region	6 months	Diagnosis made by A. L. Hoyne; first seen at Grant Hospital by H. Sauer; "ray fungus" demonstrated at Grant Hospital laboratory; born in Missouri; spent 1 month, in 1921, on farm in Wisconsin where family used flooring of old barn for kindling wood
	Elsesser, O. T., Freeport.....	Reply to letter in Illinois M. J.	♂	61	Farmer	(Wisconsin case)			
	Moorehead, F. B., Chicago....	(Oskaloosa, Iowa, case)							

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1917	15	♂	28	Farmer	West York	Illinois	Neck	7 months	Persisting sinus after several drainages of swellings in neck; actinomyces found in pus
1920	16	♂	19	Farmer	Peru	Illinois	Right temporal region	1 year	Wheat beard lodged in throat, 3 days later unable to open mouth; teeth extracted; temporal tumor developed, opened; actinomyces found in pus
1921	17	♂	55	Boiler repaired	Galena	Illinois	Sigmoid with infiltration of surrounding tissue	4½ weeks	Operated on elsewhere, pronounced malignant, although pathologist's report was "not malignant"; actinomyces fund in pus from sinus; potassium iodid given
1922	18	♂	20	Farmer	Pulaski	Minnesota	Left cheek	1½ years	Ankylosis of jaw; extensive drainage; poor prognosis; radium treatments given
1923	19	♂	42	Farmer	Carthage	Missouri	Tongue	4 weeks	Abscess on dorsum of tongue; nodule excised; pathologist's diagnosis: actinomycosis; radium and potassium iodid given

Wisconsin

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
		PUBLISHED CASES							
1886	Senn, N.*	Surg. Bact.,* 1889, p. 227.....	♂	30	Soda water manufacturer	Milwaukee	Jaw, neck, scapular region	10 months	Ruhräh, Case 18; death
1887	Ohage, J.*	Northwest. Lancet **13**: 1, 1893.....	♂	35	Captain of steamboat	Osceola	Jaw	1 year	Ruhräh, Case 25; death
1891	McGovern, W. P.*.....	M. News **60**: 99-101, 1892.....	♂	?	?	Cedarburg	Right jaw	4 months	Ruhräh, Case 13; carious tooth extracted; cured
1892	Senn, N.*	Chicago M. Rec. ?	♂	?	Farmer	Milwaukee	Jaw	5 months	Ruhräh, Case 4; excision; cured
1899	Cutler, J. S.*.....	Personal to Ruhräh.....	♀	10	Schoolgirl	Wauwatosa	Lower jaw	Few weeks	Ruhräh, Case 60; had habit of chewing grain; had carious tooth
?	Jackson, R. H.	Wisconsin M. J. **3**: 11-15, 1905.....	♂	53	Farmer	Wisconsin	Cervicofacial	?	

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
?	Jackson, R. H.	Wisconsin M. J. 3 : 11-15, 1905	♂	?	Farmer	Wisconsin	Right jaw and face	?	Lived in same house with preceding patient
?	Falge, L.	Wisconsin M. J. 7 : 710-716, 1909	♂	5	Orphan asylum	Wisconsin	Lower jaw	?	Ulcerated molars extracted
?	Falge, L.	Wisconsin M. J. 7 : 710-716, 1909	♂	10	Orphan asylum	Wisconsin	Jaw	.....	Ulcerated tooth
?	Falge, L.	Wisconsin M. J. 7 : 710-716, 1909	♂	10	Orphan asylum	Wisconsin	Jaw	.....	Author considers these three cases in one institution suggestive of transmission man to man
		PERSONAL LETTERS							
	Egdahl, A. E., Grand Forks, N. D.	Letter	♂	24	Farmer	Menomonie	Right lower jaw	1½ mos.	Sulphur granules in pus; microscopic examination revealed actinomyces; cultures negative; recovered
	Evans, E., La Crosse	Letter	♂	60	Farmer	Bridgeport	Abdomen	14 months	Appendectomy; large, indurated mass in right side; left hospital in 1 month; committed to Mendota Insane Hospital
	Evans, E., La Crosse	Letter	♂	32	Worker in flour mill	LaCrosse	Left forearm	5 years	Sewed flour sacks in mill; stabbed left arm with large needle; lesion discharged intermittently for years until abscess was excised
	Evans, E., La Crosse	Letter	♀	9	Schoolgirl	Victory	Abdomen	2½ mos.	Infection through umbilicus; large suprapubic abscess; improved for a time; death
	Evans, E., La Crosse	Letter	♀	17	Housework	Arcadia	Abdomen	2 years	Appendectomy, 1909; actinomycosis not recognized then, later affected whole abdomen and left sacro-iliac region
	Evans, E., La Crosse	Letter	♂	38	Farmer	Victory	Left jaw	?	Incision, drainage; potassium iodid given; acute symptoms
1901	Evans, E., LaCrosse	Letter	♂	45	Farmer	Bangor	Lung	1 year	Involved left lung, pleura, ribs, diaphragm and peritoneal tissue; death
1902	Marsh, C. D., Washington, D. C.	Letter in reply to published request	♂	35+	Farmer	Brandon	Lungs	?	Awn entered eye while threshing; death from tuberculosis
1909	Egdahl, A. E., Grand Forks, N. D.	Letter	♀	10	Schoolgirl	Wisconsin	Jaw	1 month	Teeth in bad condition; actinomyces found in pus; recovered
1910	Frey, G., Milwaukee	Department of Health, Madison	♂	76	?	Milwaukee	?	?	Death
1916	Evans, E., LaCrosse	Letter	♀	30	Teacher	LaCrosse	Heel	?	Small sinus in heel still persisted but no organisms found since first operation
1916	Evans, E.,† LaCrosse	Letter	♂	62	Farmer	Mauston	Right supraclavicle; later pleura	1 year	Death
1919	Gunderson, A., LaCrosse	Letter	♀	60	Housewife	LaCrosse	Chest	2½ years	Resection of eighth and ninth ribs; potassium iodid and radium given; actinomyces found in pus; death
1920	.....	St. Mary's Hospital, Milwaukee	♂	24	Dairyman	Nekoosa	9th, 10th, 11th ribs	2 years?	Appendectomy; tumor on back removed year before; pathologic report, actinomycosis
1920?	Hopkinson, R.	Letter from Milwaukee Hosptal	♀	20	Housewife	Milwaukee	Right side of face, neck and lower jaw	2 years	
1920	Boslough, A. W., Birnamwood	Department of Health	♂	34	Sales manager	Birnamwood	Lungs	18 months	Microscopic diagnosis: actinomyes in sputum; probably contracted in warehouse where hay and straw were sold
1920	Olsen, A. K., Ettrick, Wis.	?	♂	38	Machinist and blacksmith	Trempealeau	?	?	This patient seen at the Mayo Clinic; Canadian case, not counted
1921	Kaumheimer, J. G., Milwaukee.	Department of Health	♂	63	Farmer	Milwaukee (Germany)	Face, temple, cerebrum	.....	Death
1921	Gunderson, A., LaCrosse	Letter	♀	5	.....	Genoa	Abdomen	?	Actinomyces found in pus; recovered
1921	Gunderson, A., LaCrosse	Letter	♀	23	Housewife	Hillsboro	Right jaw	?	Recovered
1921	Gunderson, A., LaCrosse	Letter	♂	24	Clerk, Y.M.C.A.	LaCrosse	Jaw	.....	Actinomyces found in pus; recovered
1921	Gunderson, A., LaCrosse	Letter	♂	43	Merchant	Viroqua	Jaw	.....	Recovered

† Mayo Clinic case.

1921	Elsesser, O. J., Freeport, Ill. ..	Letter	.....	♂	61	Farmer	Clarno	Tongue	3 months	Microscopic diagnosis
	Boslough, A. W., Wausau.....	Letter	.....	♂	32	Druggist	Montana	(under Montana)		
?	Evans, E.,† LaCrosse.....	Letter	.....	♂	49	Farmer	Minnesota	(under Minnesota)		
?	Evans, E., LaCrosse.....	Letter	.....	♂	20	Farmer	Iowa	(under Iowa)		
1918	Gunderson, A., LaCrosse.....	Letter	.....	♂	27	Theological student	Minnesota	(under Minnesota)		
1919	Gunderson, A., LaCrosse.....	Letter	.....	♂	23	Farmer	Minnesota	(under Minnesota)		

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1911	20	♂	17	Farmer	Viroqua	United States	Lung and neck	9 months	Had fever, cough, discharging sinus; actinomyces present in pus
1917	21	♂	61	Farmer	Mauston	Wisconsin	Right side of neck	2 years	Diagnosed by E. E. Evans, La Crosse; death 2 years later
1917	22	♂	40	Plumber	Stockton	United States	Abdomen	10 months	Had several attacks of abdominal pain; operated on in 1916, had sinus ever since; actinomyces in pus
1917	23	♂	29	Farmer	Norwalk	Wisconsin	Right side of neck	3 years	Several "lumps" opened by home physician; sinus drained, actinomyces found in pus
1918	24	♀	19	Farmer	Hayward	Wisconsin	Liver	7 months	Death; necropsy revealed solitary actinomycotic abscess of the liver
1918	25	♀	28	Bookkeeper	Superior	Wisconsin	Right side of neck	8 months	Had lump in right submaxillary region; tooth extracted; jaw lanced several times; actinomyces found in pus
1922	26	♂	41	Farmer	Chilton	Wisconsin	Dorsum of tongue	4 weeks	Pathologic report revealed actinomycosis; radium and potassium iodid given
1923	27	♂	43	Lumberman	Park Falls	Wisconsin	Right submaxillary region	4 or 5 weeks	Actinomyces found in pus aspirated from fluctuating mass in right submaxillary region; radium and potassium iodid given
1923	28	♂	14	?	Wisconsin	.....	Left side of face and neck	12 weeks	

Minnesota

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
		PUBLISHED CASES							
1887	Ohage, J.*	Northwest. Lancet **13**:1, 1893.....	♂	29	Stone mason	Minnesota	Lungs	1 year	Ruhräh, Case 38
1892	Ohage, J.*	Northwest. Lancet **13**:1, 1893.....	♂	56	Merchant	Minnesota	Peritoneum and ileum	Few months	Ruhräh, Case 54
1907	Adair, J. H.	J. Minn. M. A. **38**:365-369, 1908.....	♂	55	Officer, state institution	Owatonna	Right jaw	10 days	Surgery and iodin locally
1919	Henrici, A. T., and Gardner, E. L.	J. Infect. Dis. **28**:232-248, 1921.....	♀	31	Housewife	Minnesota	Lungs	3 years	Acid-fast actinomyces, new species in sputum
		PERSONAL LETTERS							
?	DeBoer, H., Edgerton.....	Reply to letter in J. A. M. A.	♂	21	Farmer	Minnesota	Right lower jaw	?	Recovered
?	Evans, E., LaCrosse.....	Letter	♂	53	Farmer	Hartford	Left side of neck	2 months	Trouble began around lower wisdom tooth, incision; potassium iodid given
?	Evans, E., LaCrosse.....	Letter	♂	44	Farmer	Preston	Jaw	Few weeks	Acute; incision of abscess; curetted, packed with 1 per cent. copper sulphate; heavy doses of potassium iodid given; roentgen-ray treatment
1904	Pritchard, D. B., Winona.....	Letter	♂	43	Retired	Winona	Lung	1 year	Actinomyces found repeatedly in sputum; lived in Winona all his life; death
1911	Ahrens, E. G., Bellingham.....	Report from State Board of Health	♂	82	?	Lac Qui Parle County	Chest	10 years	Death
1912	Wietrout, I. G., Swanville.....	Report from State Board of Health	♂	47	Butcher	Swanville	Jaw	20 months	Had habit of placing knife in mouth when not using it while butchering; pus showed ray fungus; death
1915	Gardner, E. L., Minneapolis....	Report from State Board of Health	♂	35	?	Minneapolis	Lung	3 years	Death
1916	Bone, M., Kelliher.....	Report from State Board of Health	♂	38	Homesteader	Kelliher	Jaw	4 to 6 weeks	Laboratory report on direct smear and cultures did not confirm report
1916	Westby, N., Madison.....	Report from State Board of Health	♂	23	?	Lac Qui Parle County	Right iliac and inguinal region	18 months	Death
1917	Bone, M., Kelliher.....	Report from State Board of Health	♂	19	Farmer	Foy, Beltrami County	Submaxillary lymph glands	?	Report from state laboratory: smears showed organisms closely resembling actinomyces; culture not obtained

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1918	Warwick, University Hospital..	Report from State Board of Health also, L. B. Baldwin, Univ. Hosp.	♂	34	Farmer	Kilkenny	Back and appendectomy wound	1 year	Sulphur granules found in pus; death; Mayo Clinic Case 118 (under Montana)
1918	Holm, P. F., Wells.....	Letter	♂	35	?	Wells	Lower jaw	5 months	Tooth extracted; two laboratories confirmed diagnosis of actinomycosis; roentgen-ray treatments and several pounds of potassium iodid given; recovered
1918	Gunderson, A., LaCrosse.....	Letter	♂	27	Theological student	Whalen	Chest	6 months	Diagnosis of tuberculosis made at operation; abscess of chest wall; sinus drained; ray fungus found in discharge 6 months later; roentgen-ray treatments given; recovered
1919	Gunderson, A., LaCrosse.....	Letter	♂	23	Farmer	Mabel	Abdomen	2 months	Abdominal and pelvic abscess drained; sulphur bodies found; discharged
1919	Shellington, N. A., St. Paul....	Report from State Board of Health	♂	32	?	St. Paul	?	3 years	Actinomycosis; pericarditis; death
1919	List, W. E., Minneapolis.....	Minneapolis General Hospital.....	♂	30	Laborer, farmer, miner	Minnesota and Wyoming	Right lung	1 year	Sulphur bodies found in pus from arm and leg, also in sputum; death; Wyoming case (under Wyoming)
1919	Witherstine, W., Grand Forks, N. D.	Report from St. Michael's Hospital, Grand Forks, N. D.	♂	36	Meat packer	East Grand Forks and St. Paul	Lungs and liver	5 months	Diagnosis: neoplasm of right lung; necropsy revealed actinomycosis of lungs, liver and mesentery
1921	Schwyzer, A., St. Paul.....	Answer to letter in Journal-Lancet; also, report by State Board of Health	♂	26	Farmer and bricklayer	St. Paul	Right lung, pleura and chest wall	6 months	Exhausted; death; previously lived in Dakota
1921	Pelant, F. J., New Ulm.....	Report from State Board of Health	♂	35	Farmer	Milford	Right side of face	1 month	Diagnosed actinomycosis; laboratory findings negative on two examinations
1922	Sogge and Johnson, Windom..	Answer to letter in Journal-Lancet; also, report by State Board of Health	♂	82	Retired farmer	Windom	Neck	2 years	Contracted in Iowa (under Iowa)
?	Abbott, A. W., Minneapolis....	Letter	♂	40	Farmer	Delaware, New York County	Left jaw	1 month	Operation; recovered (under New York)
?	Evans, E., LaCrosse.....	Letter	♂	40	?	Houston	Perineum	10 years	Mayo clinic Case 29

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1911 also 1920	29	♂	49	Stock buyer	Houston	Wisconsin	Scrotum	10 years	Lump first noticed in perineum; diagnosed by E. Evans, La Crosse; returned in 1914, 1917 and 1920 for same trouble; pathologic diagnosis pus and tissue
1915	30	♂	38	Farmer	Amiret	Nova Scotia	Right chest	4 months	Began with cold, cough, blood streaked sputum; operated on for abscess or tumor of lung; pathologic report: actinomycosis; death
1916	31	♂	49	Farmer	Deerwood	.....	Left cheek	2½ months	Clinical diagnosis
1918	32	♂	15	Farmer's son	Spring Valley	United States	Neck	3 weeks	Pathologic report: actinomycosis
1918	33	♂	54	Carpenter	Winona	Wisconsin	Chronic pleuritis	20 months	Dorsal sinus; actinomyces found in pus; death
1920	34	♂	56	Farmer	Rochester	Minnesota	Left cheek	12 years ?	Twelve years ago had lump-jaw cattle on farm; about that time cut pimple on cheek with razor; swelling gradually increased, resulting in ankylosis of jaw; actinomyces found in pus; death
1920	35	♂	26	Bank clerk	Owatonna	.....	Right cheek	2 months	Clinical diagnosis: mass secondary to extraction of molar
1921	36	♂	45	Farmer	Zumbrota	Minnesota	Left pharynx and face	4 months	Left jaw tender; tooth extracted; rapid swelling of left nasopharynx and face; actinomyces found in pus
1921	37	♂	29	Farmer	Plainview	Minnesota	Jaw	10 days	Phlegmon on jaw opened; teeth extracted; actinomyces found in pus from abscess
1921	38	♂	55	Farmer	Palisade	Wisconsin	Anterior wall of chest and upper abdomen	15 years	Incision, drainage; roentgen-ray treatments and potassium iodid given; poor prognosis

1921	39	♂	40	Manager of oil station	Taunton	Minnesota	Base of neck	4 months	Actinomyces found in pus; radium and potassium iodid given
1921	40	♂	20	Farmer	Rochester	Russia	Neck, left cervical region	3½ months	Drainage, iodoform gauze; poor prognosis; radium treatments given
1921	41	♂	34	Farmer	Magnolia	Iowa	Right cheek	7 months	Clinical diagnosis
1921	42	♂	58	Farmer	Cologne	Minnesota	Tongue	5 years	Began after biting tongue, gradual induration; no pain; cannot protrude tongue; actinomyces found; healed sinus in right submental region
1921	43	♂	25	Cook	St. Paul	Greece	Floor of mouth, base of tongue, left side of neck	4 months	Actinomyces found in pus; curetted; radium and potassium iodid given; discharged, 1922; sinus healed
1922	44	♂	52	?	Eyota	Austria	Left lower jaw	15 months	Ankylosis of jaw; returned in 1922, when radium and potassium iodid were given
1922	45	♂	57	Farmer	Stewartville	Minnesota	Right cheek	4 days	Two years before had teeth extracted because of pyorrhea; actinomyces found in pus from sinus in right lower alveolar process; drainage; radium and potassium iodid given
1922	46	♂	28	Farmer	Vesta	Minnesota	Right side of neck	1 month	While sampling rye 2 months before examination noticed painful tickling in right side of throat; actinomyces found in pus; drainage; radium and potassium iodid given
1922	47	♂	24	Laborer	Comfrey	Minnesota	Right lower jaw	9 months	Right upper and lower third molars extracted; discharging sinus in which actinomyces were found; drainage; radium and potassium iodid given
1922	48	♂	35	Truck driver	Rochester	Minnesota	Right cheek	6 weeks	Several teeth extracted; drainage; actinomyces found in pus; radium given
1922	49	♂	17	Farmer	Kilkenny	Minnesota	Left submaxillary region	1 month	Actinomyces found in pus; drainage; radium given
1922	50	♂	34	Farmer	Blue Earth	Minnesota	Left cheek	1 year	Owned cattle having lump-jaw
1922	51	♂	44	Farmer	Minnesota	.....	Right cervical region	1 year	
1923	52	♂	28	Farmer	Grand Meadow	Minnesota	Abdomen	5 months	Appendectomy followed by draining sinus; actinomyces found in pus
1923	53	♀	22	Farmer's daughter	Minnesota	Belgium	Thoracic wall	1½ years	Breast removed, followed by sinus formation; actinomyces found in pus; death

Iowa

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1892	Minges, G.* (also personal letter to author)	Tri-State M. J., 1895, pp. 263-266.....	♀	6	.....	Dubuque	Head and neck	?	Ruhräh, Case 23 (recent notes about this case in reply to letter in J. A. M. A.)
1898	Sawyers, J. L.	J. A. M. A. **36**: 1314-1319, 1901.....	♀	29	Farmer's wife	Centerville	Jaw	2 years	Pregnancy terminated normally
1899	Sawyers, J. L.	J. A. M. A. **36**: 1314-1319, 1901.....	♂	28	?	Centerville	Neck	2 years	
1899	Sawyers, J. L.	J. A. M. A. **36**: 1314-1319, 1901.....	♂	63	Farmer	Centerville	Thumb	9 months	Thumb nail was torn off; cared for cattle having lump-jaw
1899	Sawyers, J. L.	J. A. M. A. **36**: 13-4-1319, 1901.....	♂	78	Attorney	Centerville	Jaw	2 months	Picked teeth with straw
1899	Sawyers, J. L.	J. A . M. A. **36**: 1314-1319, 1901.....	♂	58	Farmer	Centerville	Lung	1 year	Actinomyces found in sputum; injected 25 doses of potassium iodid directly into dull area; cured
1899	Sawyers, J. L.	J. A. M. A. **36**: 1314-1319, 1901.....	♂	41	Banker and cattle dealer	Centerville	Jaw	14 years	Had a swelling 14 years before when he cared for cattle having lump-jaw; had trouble with wisdom tooth 16 years before; author claims pure actinomycosis is nonsuppurative
1900	Sawyers, J. L.	J. A. M. A. **36**: 1314-1319, 1901.....	♂	30	Conductor, freight	Centerville	Jaw	1 month	
1902	Bevan, A. D., and Post, W. E..	Chicago M. Rec. **27**: 695-708, 1905....	♂	50	Farmer	Iowa	Perirectal	6 months	Abscess; death from pneumonia

PERSONAL LETTERS

1892	Minges, G.,* Dubuque.....	Personal letter; also Ruhräh.....	(Case 1 in Iowa list of published cases)			.....	.....		Ruhräh, Case 23 (additional information): disease was reproduced in abdomen of white rat with sulphur bodies in pus

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1904	Minges, G., Dubuque	Letter (with F. H. Holland).....	♂	24	Livery stable	?	Right cheek	2 years	Had habit of picking teeth with straws; infection in right cheek, also nodules in auditory canal; potassium iodid given; actinomyces found in pus
1905	Holoday, F. S., Stratford.....	Answer to letter in Dental Cosmos..	♀	20	Farmer	Iowa	Left submaxillary region	?	Tooth extracted, yellow granules found in pus, ray fungus demonstrated microscopically; recovered
1906	Minges, G., Dubuque.....	Letter (patient seen with F. W. Wieland)	♂	9	?	Dubuque	Gum	?	Tooth extracted on account of large painful swelling of gum; actinomyces found in pus; cavity in tooth also contained actinomyces (?); potassium iodid given; recovered
1907	Nelson, H. E., Dayton.....	Answer to letter in J. A. M. A.	♂	10	Farmer's son	Burnside	Jaw	?	Actinomyces found in pus; potassium iodid given by injection and by mouth; living after 15 years
?	Albert, H., Reno, Nev.	Letter	♀	11	.....	Guthrie Center	Appendix and abdominal wall	1 year and 5 months	Death; no necropsy
?	Evans, E., LaCrosse, Wis.	Letter	♂	20	Farmer	St. Lucas	Neck	4½ mos.	Barley beard under tongue, abscess formed; opened without relief; large infiltration under jaw; incision, drainage; copper sulphate and potassium iodid given
1911	Moorehead, F. B., Chicago.....	Letter	♂	50	?	Oskaloosa	Lower jaw	5 months	Tooth extracted in January, swelling continued and opened in April; mass operated on in May at Chicago; potassium iodid given; actinomyces demonstrated
1921	McNamara, F., Finley Hosp....	Answer to letter in J. A. M. A.	♂	30	Farmer	Dubuque Co.	Left jaw	6 weeks	Teeth extracted followed by swelling of jaw; treated cow for lump-jaw 6 months before; actinomyces found in pus; cured
1921	Walker, B. S., Corydon.....	Answer to letter in J. A. M. A.	♂	10	?	Corydon?	Left cheek	8 months?	Eight months before bruised cheek, slight watery discharge; later involvement about orbit; laboratory diagnosis: actinomycosis; potassium iodid given; improved
1922	Sogge and Johnson, Windom, Minn.	Reply to letter in Journal-Lancet....	♂	82	Retired farmer	Windom, Minn.	Neck	2 years	Contracted disease in Iowa; small, yellow granules in pus; treated at Windom; death
?	Crawford, R. H., Des Moines..	Answer to letter in J. A. M. A.	?	?	?	?	Gastro-intestines	?	These two patients seen at Iowa City in Dr. Romano's clinic
							? sternum	?	

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1909	54	♂	51	Druggist	Oelwein	Canada	Epigastrium	5 years	Abscess drained, followed by sinus; actinomyces found in pus; death
1914	55	♂	41	Farmer	Webster City	Ireland	Left side of neck	3 months	Some ankylosis; teeth removed; actinomyces found in pus
1916	56	♂	49	Carpenter	Hampton	Iowa	Lungs and jaw	5 years	Had abscessed tooth 5 years before; home doctor diagnosed actinomycosis; lump on left jaw persisted after the tooth was extracted; actinomyces found in sputum
1917	57	♂	58	Farmer	Sidney	United States	Left side of neck	2½ months	Submaxillary; nodular mass with draining sinus; actinomyces in pus
1917	58	♀	53	Housewife	Clinton	Canada	Appendix and abdomen	2 years	Diagnosis of actinomycosis from tissue removed at operation
1917	59	♀	30	Housewife	Des Moines	Missouri	Liver and right breast	1 year	Infection may have arisen from pelvic condition; abscess drained in right upper quadrant; death
1918	60	♀	17	Farmer's wife	Clarksville	Iowa	Right cheek	7 weeks	Small lump on jaw; tooth extracted; pus drained inside of mouth; actinomyces found in pus
1919	61	♂	71	Stone cutter	Keokuk	Sweden	Submental	2½ months	Pathologist's report, actinomycosis

1919	62	♀	63	Implement dealer	Whittemore	Wisconsin	Tongue	2 months	Pathologist's report, actinomycosis
1921	63	♂	38	Farmer	Jesup	Ireland	Right cheek	3 months	Phlegmon of right cheek; teeth extracted; actinomyces found in pus from draining sinus; cared for cattle with lump-jaw 7 years ago
1921	64	♀	24	Chiropractor	Webster City	United States	Right jaw with intracranial involvement	2½ years	Diagnosed elsewhere; ankylosis; died of meningitis 36 days after examination
1921	65	♀	60	Farmer's widow	Lenox	Canada	Left side of neck	9 weeks	Excised by home physician 7 weeks before; actinomyces found in pus; radium and potassium iodid given; poor prognosis
1922	66	♂	24	Coal miner	Cincinnati	Missouri	Central nervous system; right side of face	7 years	Ankylosis of the jaw; actinomyces found in discharge; fifty Alpine sunlight lamp treatments given before coming to clinic; radium and potassium iodid were given; cerebral symptoms noted 6 weeks before; died 6 months after examination
1922	67	♂	37	Farmer	Grand River	Iowa	Left anterior cervical region	2 months	Actinomyces found in wound; potassium iodid and radium given; much improved
1922	68	♂	32	Farmer	Waterloo	Iowa	Left submaxillary region	8 weeks	For 6 months owned cow having lump-jaw; did not treat it; had habit of chewing grass and straw; drainage; radium and potassium iodid given

Missouri

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
?	Jensew, V. W., and Schery, C. W.	J. A. M. A. **75**: 1470-1472, 1920.....	♀	24	?	Missouri	Face	?	Trouble began with toothache following picking teeth with straw; methylene blue internally and roentgen-ray treatments locally
1920	Bell, H. H.	J. Infect. Dis. **30**: 99-106, 1922.....	♂	44	Traveling salesman	Missouri	Lungs and meninges	.....	Necropsy: actinomyces in meninges and lungs; cultured, first grew anaerobically, then aerobically; never completely alcohol-fast nor acid alcohol-fast

PERSONAL LETTERS

1906	Morroway, J. H., Ridgeway....	Answer to letter in J. A. M. A.	♂	35	Farmer	Harrison Co.	Right hand	6 weeks	Owned cow having lump-jaw; sulphur bodies found in pus; potassium iodid given; cured in 20 days
1909	Shaw, F. W., Rollo.....	Reply to letter in Missouri M. J.	♂	70	Farmer	South Dakota	(under South Dakota list)		
1917	Burlingham, L. H., St. Louis..	Report from Barnes' Hospital.....	♂	35	Miner	Missouri	Neck	13 weeks	Two teeth extracted; incision, drainage, roentgen-ray treatment; improved 2½ months after discharged
1918	Burlingham, L. H., St. Louis..	Report from Barnes' Hospital.....	♂	38	Laborer in brewery	St. Louis	Abdominal wall	13 weeks	Incision, drainage infection of abdomen; left hospital against advice and died 6 weeks later
1920	Burlingham, L. H., St. Louis..	Report from Barnes' Hospital.....	♂	48	Laborer	St. Louis	Lung	4½ mos.	Died after 6 weeks in hospital for thoracostomy, etc.; necropsy: actinomycosis involving hilum of left lung and pleura with extension into diaphragm, retroperitoneum and left psoas muscle
1920	Steckbauer, J. W., St. Louis...	Personal reply from City Hospital..	♀	24	Housework	St. Louis	Left jaw	1 month	Trouble began with toothache; tissue report, actinomycosis; sulphur granules found after roentgen-ray treatment; patient pregnant; improved
1921	Morroway, J. H., Ridgeway....	Personal reply to letter in J. A. M. A.	♂	16	Farmer's son	Harrison Co.	Right thumb	?	Sulphur bodies found in pus; no microscopic examination
1922	Steckbauer, J. W., St. Louis...	Personal reply from City Hospital..	♂	62	None	St. Louis	Right side of neck	4 months	Laboratory diagnosis: actinomycosis; remained under observation only 5 days
1923	Motzal, A. J., St. Louis.....	Reply to letter in Missouri S. J.	♀	17	Telephone operator	St. Louis	Lung	Years ?	Sulphur bodies found in sputum; diagnosed as "streptothrix"

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1916	69	♂	47	Farmer	Meaderville	United States	Region of appendix	9 months	Had dull, grinding pain in region of appendix in September, 1915; induration increased; confined to bed, December 31; appendectomy, January 24; opened and drained several times; actinomyces found in pus; death
1916	70	♀	18	Farmer	Milligrove	Missouri	Region of appendix	1½ years	Pain in right side, April, 1915; appendectomy, July, 1915; opened; actinomyces found in pus; death
1917	71	♂	58	Farmer	Albany	United States	Left submaxillary gland	5 weeks	Two teeth extracted; partial ankylosis; pathologist reported actinomyces; large gland
1919	72	♂	67	Farmer	Pilot Grove	Missouri	Left parotid region	3 months	Trouble started inside mouth; ankylosis; tumor mass opened and actinomyces found in pus
1920	73	♂	16	Farmer	Union Star	Missouri	Left maxillary region	6 months	Indurated abscess of jaw; opened several times and actinomyces found in pus
1922	74	♂	45	Engineer	St. Joseph	Kansas	Right base of tongue	2 months	Trouble began with piece of tobacco stem sticking in tongue; actinomyces found in pus from sinus in right floor of mouth posteriorly; radium and potassium iodid given; greatly improved
1922	75	♂	62	Farmer	Perry	Wisconsin	Phlegmon of submental region	2 months	Diagnosed clinically as actinomycosis; treated with potassium iodid

CENTRAL STATES (NORTHWEST PORTION)

North Dakota

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
?	Ramsted, N. O.	Journal-Lancet **36**: 732-735, 1916.....	♂	28	Photographer	North Dakota	Jaw	5 weeks	Actinomyces in pus; chewed grass; recovered
?	Ramsted, N. O.	Journal-Lancet **36**, 1916.....	♂	54	Farmer	North Dakota	Lower right jaw and lungs	3 months	Actinomyces in pus and sputum; recovered
?	Ramsted, N. O.	Journal-Lancet **36**, 1916.....	♂	62	Farmer	North Dakota	Lower right jaw	4 weeks	Actinomyces in pus; recovered
?	Ramsted, N. O.	Journal-Lancet **36**, 1916.....	♂	46	Farmer and stockman	North Dakota	Lung	3 months	Actinomyces in sputum; cured
?	Ramsted, N. O.	Journal-Lancet **36**, 1916.....	♀	8	.....	North Dakota	Neck	6 weeks	Actinomyces in pus
?	Ramsted, N. O.	Journal-Lancet **36**, 1916.....	♂	19	Farmer	North Dakota	Lungs and abdomen ?	2 weeks ?	Died

PERSONAL LETTERS

Source	Sex	Age	Occupation	Residence	Location of Lesions	Duration of Symptoms	Remarks
Bismarck Hospital	♂	23	Farmer	North Dakota	Neck	3 years	Roentgen-ray treatments and potassium iodid given; cured
Bismarck Hospital	♂	45	Farmer	North Dakota	Jaw	2 months	Incision; potassium iodid given; cured
Bismarck Hospital	♂	24	Farmer	North Dakota	Neck	1 month	Incision, curettage; potassium iodid given; cured
Bismarck Hospital	♂	36	Merchant	North Dakota	Face	2 months	Incision; roentgen-ray treatments and potassium iodid given; cured
Bismarck Hospital	♀	40	Housewife	North Dakota	Lump in breast	.....	Partial resection; potassium iodid given; cured
Bismarck Hospital	♂	56	Farmer	North Dakota	Jaw	3 months	Excision; potassium iodid given; died; necropsy: general involvement of all glands
Bismarck Hospital	♂	16	Student	North Dakota	Neck	6 months	Incision; potassium iodid given; cured
Bismarck Hospital	♀	8	Student	North Dakota	Neck	6 months	Cauterization; potassium iodid given; cured
Bismarck Hospital	♂	10	Farmer	North Dakota	Upper left abdomen	2 weeks	Drainage; potassium iodid given; died
Bismarck Hospital	♂	62	Farmer	North Dakota	Neck	2 months	Incision, curettage; potassium iodid given; cured
Bismahck Hospital	♂	54	Farmer	North Dakota	Neck	6 weeks	Curettage; potassium iodid given; cured
Bismarck Hospital	♂	35	Farmer	North Dakota	Abdomen	5 days	Drainage; roentgen-ray treatments and potassium iodid given; died at Rochester, Nov. 4, 1919 (Mayo Clinic Case 86)
Bismarck Hospital	♂	22	Well driller	North Dakota	Jaw	1 month	Cauterization; potassium iodid given; cured
Bismarck Hospital	♂	45	Farmer	North Dakota	Jaw	3 weeks	Incision; potassium iodid given; cured
Bismarck Hospital	♀	23	Housewife	North Dakota	Abdomen	3 months	Potassium iodid given (Mayo Clinic Case 84)
Bismarck Hospital	♂	72	Farmer	North Dakota	Hand	4 years	Partial amputation; roentgen-ray treatments and potassium iodid given; cured
Bismarck Hospital	♂	36	Realtor	North Dakota	Scrotum	1 year	Orchidectomy; potassium iodid given; cured

Bismarck Hospital	♀	9	Student	North Dakota	Chronic empyema	5 months	Potassium iodid given; results unknown
Bismarck Hospital	♀	34	Housewife	North Dakota	Lower abdomen	9 days	Drainage; potassium iodid given; results unknown
Bismarck Hospital	♂	18	Farmer	North Dakota	Neck	2 weeks	Incision; curettage; roentgen-ray treatments and potassium iodid given; cured
Bismarck Hospital	♀	12	Student	North Dakota	Neck	2 months	Curettage; potassium iodid given; cured
Bismarck Hospital	♂	10	Student	North Dakota	Abdomen	10 days	Drainage; potassium iodid given; died

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
	McCannel, A. D.	Minot Hospital	♂	11	Student	Mohal	Jaw, hands and elbow	3 years	Deformity of jaw with partial ankylosis; sulphur bodies present
	Brimi, C. L., Cooperstown.....	Reply to letter in J. A. M. A.	♂	22	Farmer	North Dakota	Jaw	2 months	Handled great many cattle; actinomyces found; recovered
	Witherstine, W. H., Grand Forks	St. Michael's Hospital.....	♂	36	Meat packer	Minnesota	(under Minnesota)		

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1913	76	♂	43	Farmer	Ryder	Norway	Right jaw	7 weeks	Ankylosis; actinomyces found in pus
1916	77	♂	21	Farmer	Beulah	Minnesota	Left side of neck	5 weeks	Actinomyces in discharge
1916	78	♂	9	.....	Hague	.....	Left cheek and submental region	1 year	Clinical diagnosis
1917	79	♂	44	Farmer	Peterburg	Indiana	Right side of neck	3 months	Treated cow having lump-jaw; nodule on right side of larynx
1918	80	♀	43	Farmer	New England	Minnesota	Abdominal wall involving intestines	5 months?	Actinomyces found in pus, verified in pathologist's report
1919	81	♂	38	Farmer	Cartwright	Norway	Left neck	6 months	Clinical diagnosis: lump on anterior cervical region
1920	82	♂	56	Farmer	Hankinson	Minnesota	Right side of neck	7 months	Mass in neck drained several times; actinomyces found in pus
1920	83	♂	53	Farmer	Nome	Norway	Left cheek	2 months	Tooth extracted, after which mass formed on left cheek; actinomyces found in pus; cattle did not have lump-jaw
1921	84	♀	23	Merchant	Dickinson	Russia	Peritoneum, secondary to appendix (or tubes)	3 years	Appendectomy and salpingectomy for sudden pain in right lower quadrant; second operation for pain in left side; sinus drained; actinomyces found in pus
1922	85	♂	35	Farmer	Oakes	Kentucky	Subphrenic abscess; liver, lungs, brain	3 months	Appendectomy, July, 1921; died, Feb. 6, 1922
1922	86	♀	33	Farmer's wife	Crosby	South Dakota	Left cheek and side of face	4 months	Ankylosis of left jaw; drainage; radium treatments and potassium iodid given
1922	87	♂	42	Farmer	Hamlet	Minnesota	Left side of neck	8 months	Abscess drained four times; radium treatments and potassium iodid given
1923	88	♂	19	Student (carpenter's son)	Abercrombie	.....	Right upper cervical region	About 4 months	

South Dakota

No cases reported in the literature

PERSONAL LETTERS

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1909	Shaw, F. W., Rolla, Mo.	Reply to letter in Missouri S. J.	♂	70	Farmer	South Dakota	Lower jaw	.....	Previously diagnosed carcinoma
1920	Gunderson, A., LaCrosse, Wis.	Personal letter	♂	16	Student	Hetland	Neck	5 months	Swelling appeared 3 months prior to examination; died 2 months later

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1913	89	♂	21	Laborer	Carthage	United States	Right side of neck	2 months	Discharging sinus; pathologist's report: actinomycosis; 2 years before examination, owned a cow with lump-jaw
1917	90	♂	26	Farmer	Freeman	South Dakota	Left side of neck	4 months	Swelling noticed on left side of neck; lower left molar was infected and actinomyces found in the pus

MAYO CLINIC CASES—Continued

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1917	91	♂	19	Clothier	Parkston	United States	Left cheek and jaw	3½ months	Tooth pulled followed by cellulitis; had a draining sinus at angle of jaw; actinomyces found in pus
1917	92	♂	40	Farmer	Gettysberg	Iowa	Left parotid region	3 years	Clinical diagnosis
1917	93	♂	42	Farmer	Harrison	Iowa	Neck	7 weeks?	Actinomyces found in pus from enlargement of left side of neck
1917	94	♂	34	Farmer	Presho	Illinois	Neck	1 year	Sinus following incision in lump on neck; actinomyces found in pus
1918	95	♂	52	Farmer	Chamberlain	Germany	Left temporal region	1½ years	Some ankylosis; many drainages
1918	96	♀	51	Farmer	Brandt	Germany	Right side of neck	8 months	Swelling found in submaxillary region; actinomyces discovered in pus
1919	97	♂	49	Farmer	Athol	Iowa	Left side of neck	11 months	Operated on animals with lump-jaw
1920	98	♂	45	Rancher	Mobridge	South Dakota	Right side of neck	5 weeks	Fluctuating mass in the neck; actinomyces found in pus
1920	99	♂	25	Laborer	Freeman	South Dakota	Right temporal region, spinal cord, lungs	6 months	Trouble began in temporal region, then over right eye, followed by deafness and meningitis; incision made in temporal region; brain uncovered; actinomyces found in pus; died; necropsy confirmed diagnosis
1920	100	♂	55	Farmer	Sisseton	Wisconsin	Submaxillary	6 weeks	Painful mass
1921	101	♂	9	School boy	Sturgis	South Dakota	Neck	11 months	Sinus; actinomyces found in pus; died, March 23, 1922
1921	102	♂	32	Farmer	Sinai	South Dakota	Right cheek	3 months	Lump on jaw; sinus; actinomyces found in pus; had cattle with lumpy jaw; had habit of chewing straws
1921	103	♂	53	Farmer	Pukwana	Germany	Region of appendix	3 years	Postoperative sinus; actinomyces found in pus; radium treatments and potassium iodid given; Died, June 25, 1922
1922	104	♂	34	Farmer	Vyborg	Denmark	Subdiaphragmatic abscess	3 years	Actinomyces found in pus; sinus from appendectomy; large doses of potassium iodid advised
1922	105	♂	29	Carpenter	Elk Point	South Dakota	Abdomen and lungs	1 year	Appendectomy, March, 1922; right thoracotomy
1922	106	♂	18	Farmer	Winner	United States	Perinephritic and subphrenic abscess	8 months	Died, Jan. 8, 1923; necropsy: abscess of right kidney; multiple embolic abscesses of lungs, acute diffuse nephritis, multiple abscesses of liver; actinomyces found in pus; grandfather stated that lump-jaw cattle were present on ranch
1923	107	♂	37	Laborer	Lake Preston	Germany	Nasopharynx	6 months	Painless swelling in front of left ear
1923	108	♂	61	Farmer	St. Lawrence	Illinois	Tongue	6 weeks	Primary lesion in tongue; excised; radium treatments given; cured

Kansas

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1908	Basham, D. W.	West. M. Rev., December, 1920.....	♂	30	Farmer	Toronto	Neck and jaw	3 months	Trismus; actinomyces found in pus from abscess; cured
? 1917	Warthin, A. S., and Olney, H. S. Case 114	Am. J. M. Sc. **128**: 637-649, 1904.....	♂	45	Farmer	Kansas	Lungs	3 years	Diagnosed tuberculosis; went to Colorado; seen by Dr. King of Pueblo; branching organism acid-fast but not acid alcohol-fast; died; material sent to Dr. Warthin
1915	Sudler, M. T.	J. Kansas M. S. **16**: 326-329, 1916....	♂	20	? (negro)	Rosedale	Lumbar region and appendix	?	Appendiceal abscess
1918	Mattson, W. W.	Surg., Gynec. & Obst. **34**: 482-494, 1922	♂	29	Horseshoer	Ft. Riley	Abdomen	6 months	Appendectomy and two other explorations; actinomyces found in discharge from sinus; tip of appendix had concretion about a piece of wheat grain

PERSONAL LETTERS

?	Basham, D. W.	Letter	♂	?	Farmer	Toronto	Tongue	2 weeks	Had treated cattle for lump-jaw
?	Cole, J. C., Topeka.....	Reported by E. G. Brown, health officer; also by Dr. S. J. Crumbine	♂	?	Butcher	Kansas	Right lower jaw	1 year	Laboratory confirmed diagnosis
1910	Bowen, W. F., Topeka.....	Letter	♂	26	Cowboy	Maple Hill	Jaw ?	5 weeks	Roentgen-ray treatment; recovered
1913	Bowen, W. F., Topeka.....	Letter	♂	?	Farmer	Meriden	Jaw	5 weeks	Roentgen-ray treatments given; recovered

1913	Bowen, W. F., Topeka	Letter	♂	53	Traveling showman	?	Left forearm	4 months	Recovered
1914	Johnson, H. B., Pomona	Reply to letter in J. A. M. A.	♂	27	Farmer	Kansas?	Jaw	1 month	Actinomyces found in pus; potassium iodid given; recovered
1916	Bowen, W. F., Topeka	Letter	♀	26	Rancher's wife	Maple Hill	Middle finger of left hand	6 weeks	Husband dressed sore on neck of bull, washed hands in family wash basin; patient's finger infected; recovered
1916	Bowen, W. F., Topeka	Letter	♂	19	Farmer	Scranton	Abdomen	?	Actinomyces found in pus; appendectomy; recovered
1916	Sudler, M. T., Rosedale	Reply to letter	♂	24	Hotel porter	Lawrence	Abdominal	6 months	Pathologic report revealed actinomycosis; cultures failed to grow
1919	Hogeboom, Topeka	Suggested by health officer, E. G. Bowen	♂	18	Student	Kansas	Right jaw	4 months	Chewed chaff of wheat; father owned two cows having lump-jaw; died; actinomyces found in tissue
1920	Bowen, W. F., Topeka	Letter	♂	?	Farmer	Bazar	Neck	?	Actinomyces found; recovered
1920	Bowen, W. F., Topeka	Letter	♂	24	Dentist	Wamego	Jaw	Several weeks	Had tooth extracted; pain increased, abscess behind and below angle of jaw was opened and drained; actinomyces found in pus
1921	Johnson, H. B., Pomona	Reply to letter in J. A. M. A.	♂	52	Farmer	Pomona ?	Jaw	2 months	Actinomyces demonstrated; recovered
1921	Miller ?	Dr. Brown, health officer, also S. J. Crumbine	♂	25	Furniture packer and upholsterer	Kansas 1 year	Jaw	6 months	Tore up old furniture that was dirty and stuffed with hemp; diagnosis confirmed by laboratory findings
					MAYO CLINIC CASE				
1920	Case 109		♂	39	Farmer	Dunlap (Native of Kansas)	Left side of neck	6 months	Persistent sinus following incision of swelling in left side of neck

Nebraska

PUBLISHED CASES

1918	Wohl, M. G.	Nebraska M. J. 4 : 134-136, 1919	♂	68	Farmer	Nebraska	Inside lower lip and submaxillary gland	1½ mos.	Blood agar, glucose agar and glucose bouillon cultured anaerobically; autogenous vaccine; potassium iodid and sodium cacodylate given; improved
1919	Baskin, M. J.	J. A. M. A. 78 : 1367-1368, 1922	♂	35	Farmer and trapper	Alliance	Left hand	1 week	Fungus in pus from nodule; lesion healed in 2 weeks

PERSONAL LETTERS

1917	Vickers, F. D., Deming, N. M.	Letter	♀	29	Grocery clerk	Nebraska	Mouth and throat	4 years	Went to New Mexico for health; lungs probably involved; large doses of potassium iodid given; cured
?	Wohl, M. G.	Personal communication	♂	58	Farmer	Nebraska	Right side of neck	4 months	Actinomyces demonstrated; complete recovery
?	Wohl, M. G.	Personal communication	♂	25	Mail carrier	Omaha	Right side of face	4½ mos.	Actinomyces found in tissues and in pus; recovered

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1913	110	♂	25	Farmer	Petersburg	Nebraska	Thigh and lung	6 months	Fluid from hip and lung showed actinomyces; infection probably into liver
1916	111	♂	44	Farmer	Lincoln	Iowa	Left side of neck	1 year	Nodular tumor; incised by home doctor; actinomyces found in pus
1916	112	♂	20	Farmer	Ainsworth	Nebraska	Right jaw and neck	7 months	Several teeth extracted following swelling of jaw; abscess lanced and drained continuously; actinomyces found in pus
1916	113	♂	36	Farmer	Cedar Rapids	Nebraska	Left cheek	2 months	Ankylosis of jaw; two teeth were extracted; a mass was discovered in the temporal region; actinomyces found in pus

SOUTHERN STATES

Tennessee

PUBLISHED CASES

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1898	Walker, J. E.*	Memphis Lancet, November, 1898....	♀	?	Dairy maid	Tennessee	Left side of face	2 years	Ruhräh, Case 68

PERSONAL LETTERS

	Bethea, W. R., Memphis.....	Tri-State Baptist Memorial Hospital	♂	45	Farmer	Arkansas	(under Arkansas)		
	Bethea, W. R.	Tri-State Baptist Memorial Hospital	♂	44	Merchant	Mississippi	(under Mississippi)		
	Bethea, W. R.	Tri-State Baptist Memorial Hospital	♂	46	Druggist	Memphis	Right of umbilicus	10 years	In bed most of time; tuberculin tests negative
	Lowden, C. N.	Nashville Hospital	♂	19	Farmer	Tennessee	Abdomen	10 months	Injury
1916	King, J. M., Nashville.....	Reply to published request.....	♂	34	?	Tennessee	Tongue	6 years	Tissue examined showed actinomycosis; iodin and roentgen-ray treatment; potassium iodid given internally; recovered
1921	Lucretia Spears, Asst. Record-Librarian	Memphis General Hospital.....	♀	25	Cook	Memphis	Abdomen	Several weeks	Colored; died

Arkansas

?	Warren, G. A.	Hot Springs M. J. **12**: 100-102, 1903..	?	?	?	?	?	?	Could not get copy of history
?	Bethea, W. R.	Baptist Memorial Hospital.....	♂	45	Farmer	Helena	Side of neck and back	3 years	Roentgen-ray treatment; cured (syphilis 30 years before)

Alabama

PUBLISHED CASE

?	Hudson, W. H., and Flexner, S.	Ann. Surg. **26**: 626-633, 1897.....	♂ (negro)	62	Gardener	Lafayette	Back and lungs	18 years	Slept on straw pile; necropsy confirmed diagnosis

PERSONAL LETTERS

1922	Helvig, G.	St. Vincent's Hospital, Birmingham.	♀	28	Stenographer	Birmingham	Outside right hip	3 years	Excised twice; treated
1922	Sister Rose	Providence Infirmary, Mobile.....	♂	61	Farmer	St. Elmo	Right lower jaw	3 months	Remained in hospital 4 days only

Mississippi

PERSONAL LETTERS

?	Sister Rose, Mobile.....	Personal letter from Providence Infirmary	♂	21	Farmer	Lucedale	Tongue and mucosa of mouth	9 months	Died 2½ months after leaving hospital
	Bethea, W. R., Memphis, Tenn.	Baptist Memorial Hospital, Memphis, Tenn.	♂	44	Merchant	Love Station	Lip		
1922	Spelman, J. D., New Orleans...	Reported from Touro Infirmary.....	♀	36	Housewife	Biloxi	Liver, right lung, right pleural space, pleura and chest wall	2 years	Actinomyces in fresh stained specimen; culture showed actinomyces; discharged greatly improved

Oklahoma

PUBLISHED CASES

1914	Roth, A. W.	J. Oklahoma M. A. **9**: 9, 1916.....	♀	22	Housewife	Oklahoma	Tongue	?	Actinomyces present
1918	Riley, J. W.	Bull. St. Anthony's Hosp. **1**: 25-27, 1920	♀	36	?	Oklahoma City	Abdomen	6 or 7 months	Exploratory operation; appendix not removed- died; necropsy: actinomyces in hepatic abscess; cultured

?	Von Wedel, C.	Bull. St. Anthony's Hosp. **1**: 27-30, 1920	♂	14	.....	Oklahoma City	Right hip and iliac region	3 or 4 months	"Streptothrix" found; cultured
					PERSONAL LETTERS				
1906	Spence, W. P., Kaw City	Reply to letter in J. A. M. A.	♂	60	?	Nevada	(under Nevada)		
1909	Spence, W. P., Kaw City	Reply to letter in J. A. M. A.	♂	25+	Farmer	Colorado	(under Colorado)		
1919	Sister Mechtildis	St. Anthony Hospital, Oklahoma City	♂	14	.....	Oklahoma	Pelvis	3 months	Actinomyces in pus; died; cultures at necropsy positive; previous cultures negative
1920	Hardy, H., Poteau	Reply to letter in J. A. M. A.	♂	57	Cobbler	Oklahoma	Finger	Several weeks	Actinomyces in pus; abrasion of skin thought to have been inflicted while butchering
1920	Pearce, C. M., Calumet	Reply to state journal	♂	21	?	Oklahoma	Right jaw	7 months	Face swollen, unable to open mouth; actinomyces in pus; died
1920	Sister Mechtildis	St. Anthony Hospital, Oklahoma City	♀	40	Housewife	Oklahoma	Abdominal	3½ mos.	Tumor mass outside peritoneal cavity in right iliac region; actinomyces in pus
1922	Langston, W., Oklahoma City.	State University Hospital, Oklahoma City	♂	27	Oil worker	Oklahoma	Abdominal	2 years	Lived on a farm; actinomyces demonstrated in discharge after many examinations; improved
1922	Langston, W., Oklahoma City.	State University Hospital, Oklahoma City	♂	9	.....	Oklahoma	Jaw	10 months	Had tooth pulled. 30 days later cheek was lanced; actinomyces in pus; recovered
					MAYO CLINIC CASE				
1917	Case 114	.....	♂	23	Barber	Sapulpa	Left cheek	3 years	Abscessed tooth extracted; jaw failed to heal; swelling of left side of face; two external operations from which came sulphur bodies
					Louisiana				
					PERSONAL LETTERS				
1921	Spelman, J. D., New Orleans	Touro Infirmary	♀	26	Housewife	Florida	(under Florida)		
1921	Spelman, J. D., New Orleans	Touro Infirmary	♀	50	Housewife	Louisiana	Right lung	A few months	Pneumonia 2 months before; died 2 months later; necropsy revealed actinomyces
1922	Spelman, J. D., New Orleans	Touro Infirmary	♀	36	Housewife	Mississippi	(under Mississippi)		
1922	Leake, W. F., New Orleans	Charity Hospital	♂	51	Seaman pipe fitter	Austrian?	Head and neck	7 weeks	Died after 2 weeks in hospital
					Texas				
					PUBLISHED CASES				
1916	Eskridge, B. C.	S. Texas M. Rec. **10**: 16, 1916; also, personal letter from author	♂	28	Teacher (negro)	Houston	Jaw	3 months	Trismus, unable to open mouth; had been in school in Florida
1920	Cadwallader, J. M.	Texas S. J. M., 1921	♀	15	.....	Texas	Jaw	10 weeks	Had habit of chewing grain; molar tooth extracted and actinomyces found in pus
					PERSONAL LETTERS				
?	Twitchell, J. C., Austin	Board of Health	♂	44	Dray driver	San Antonio	Lungs and liver	2 years and 3 months	Had lived in state 24 years
1921	Moursund, W. H.	Baylor University, Dallas	♂	58	Draftsman	Dallas	Left chest	6 months	Pathologic report: actinomycosis of chest wall
1921	Graves, M. L.	John Sealy Hospital, Galveston (J. E. Thompson's case)	♂	21	Auto mechanic	Breckenridge	Face	2 months	Actinomyces in pus
					MAYO CLINIC CASE				
1921	Case 115	.....	♀	34	Housewife	Emerillo	Pelvis	2 years	Salpingectomy and appendectomy; sinus; actinomyces in pus

PLATEAU STATES

Montana

PERSONAL LETTERS

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
1907	O'Malley, P. H., Chinook.....	Personal reply to published request; Orthodontic News and Notes	♂	18	Ranchman	Milk River Valley	Right jaw	4 months	Actinomyces found in pus; 1 per cent. copper sulphate in sinus; iodoform gauze pack; from 10 to 180 grains (0.7 to 12.6 gm.) potassium iodid given daily
1914	Worstell, G., Big Sandy.....	Personal reply to letter in J. A. M. A.	♂	51	Physician	Big Sandy	Lower jaw	2 months	Sulphur bodies present in pus; had the habit of chewing wheat, hay or grass
1916	O'Malley, H. P., Chinook.....	Personal reply to published request	♂	25	Machine salesman	Montana	Left jaw	5 or 6 weeks	Came to Montana from Idaho (under Idaho), where he probably contracted the disease; 180 grains (12.6 gm.) potassium iodid given; cured
1920	Gunderson, A., LaCrosse, Wis.	Personal letter	♂	37	Locomotive fireman	Glendive	Liver	?	Died
1921	Moirus, A. J., Billings.....	Report Dept. Pub. Health, Helena...	♂	78	Farmer	Billings	Right mandible	1 year	Roentgen-ray treatment; actinomyces in pus; died
1921	Cottom, F. W., Lewistown.....	Report Dept. Pub. Health, Helena...	♂	36	Laborer	Lewistown	?	?	Report to health officer of actinomycosis; "notifiable disease"
1921	Judd, H. H., Bozeman.....	Report Dept. Pub. Health.....	♂	25	Farmer	Bozeman	Jaw, cheek and neck	5 months	Cow with lump-jaw in herd; sanitary habits not good; ray fungus in discharge
1922	O'Malley, P. H., Chinook.....	Personal letter in reply to published request	♂	32	Rancher	Montana	Right jaw	5 months	Had habit of pulling grass growing around stock watering holes and chewing it; cured
	Marsh, C. D., Washington, D. C.	Paper by D. M. Knowles, Breeder's Gaz., Feb. 22, 1910	?	..	?	Data incomplete			

MAYO CLINIC CASES

Year	Case	Sex	Age	Occupation	Residence	Nativity	Location of Lesions	Duration of Symptoms	Remarks
1916	116	♂	30	Farmer	Helena	Montana	Neck	3 months	Tumor in right submaxillary region; actinomyces in pus
1916	117	♂	43	Farmer	Columbus	Iowa	Right side of neck	3 months	Six months before examination was struck in neck, swelling noticed 3 months later; pus contained actinomyces
1916	118	♂	43	Bookkeeper	Helena	United States	Cecum and appendix	1 year ?	Symptoms noticed 1 year and also 9 years before; appendectomy 8 months before; pathologic report: granuloma; fluctuating mass in appendiceal region; actinomyces present ?
1917	119	♂	27	Farmer	Opheim	Norway	Right side of neck	6 months	Mass at top of sternum; had several operations; discharging sinuses; actinomyces in pus
1917	120	♂	47	Farmer	Glendive	Wisconsin	Right temporal region	?	Swelling opened several times and drained; actinomyces found in pus
1917	121	♂	36	Farmer	Enid	Minnesota	Appendiceal fistula	5 months	Ruptured appendix followed by draining sinus; 3 years before owned cow with lump-jaw; contaminated his fingers with pus and handled his tobacco; actinomyces in pus and tissue; died
1917	122	♂	34	Farmer	Gregeson	Austria	Left cheek	2 months?	Ten years before examination, had abscess on neck; 2 months before examination, small lump on left cheek was opened and actinomyces found in pus
1919	123	♂	17	Farmer	Joliet	Missouri	Left cheek	9 months	Jaw ankylosed; drainage started following removal of wisdom tooth
1919	124	♂	18	Farmer	Joliet	Illinois	Submental region	2½ months	Gradual painless swelling of neck
1920	125	♂	50	Stock raiser	Forsyth	Illinois	Right side of neck	9 months	Draining sinus; actinomyces found in pus
1920	126	♂	30	Telegraph operator	Livingston	Wisconsin	Cecum and abdominal wall	5 years	Symptoms of chronic appendicitis; abscess drained; appendectomy; sinus; actinomyces found in pus
1921	127	♂	24	Farmer	Shawmut	Missouri	Left side of neck	4 months	Two teeth removed because of pain in jaw; ankylosis; phlegmon submaxillary region (left); actinomyces found in pus; died of meningitis
1922	128	♂	40	Farmer	Winett	United States	Chest	2½ years	Empyema in 1921, thoracotomy; sinus showed actinomyces; poor prognosis

Idaho

No cases reported with possible exception of case reported by Dr. H. P. O'Malley, Chinook, Mont.

Wyoming

PERSONAL LETTERS

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
	Halley, C. R., Sheridan.....	Reply to letter in J. A. M. A.	♀	40	Housewife	Sheridan	Left sternum (upper part)	1 year	Ray fungus abundant
1919	List, W. E.	General Hospital, Minneapolis.....	♂	30	Labor, miner, farmer	Wyoming	Right lung	.....	Actinomyces in pus; died in Minneapolis

MAYO CLINIC CASE

1919	Case 129	.....	♂	24	Rancher	Wyoming	Right submaxillary and cervical regions	?	Dug at tooth with straw

Nevada

PERSONAL LETTERS

1906	Spence, W. P., Kaw City, Okla.	Reply to letter in J. A. M. A.	♂	60	?	Nevada	Penis	2 years	Sulphur granules in pus
?	Albert, H., Reno.....	Personal communication	♂	36	?	Reno	Cecum and abdominal wall	1 month and 19 days	Death; necropsy

Utah

No cases reported.

Colorado

PERSONAL LETTERS

?	Whitman, R. C.	Personal letter to University of Colorado, Boulder	♂	?	Farmer	Colorado	Submaxillary gland	?	Operated on by Dr. C. B. Lyman; sulphur bodies demonstrated
1909	Spence, W. P., Kaw City, Okla.	Reply to letter in J. A. M. A.	♂	25+	Farmer	Colorado	Jaw	Several months	Diagnosis not verified; choked to death in coughing spell
1910	Edwards, E. G., Denver.....	J. A. M. A. 54:1308, 1910; also, personal letter from author	♂	26	Cowboy	Colorado	Skin	Several weeks	Probably contracted in California; ray fungus found in discharge; treated surgically, incision, curettage, swabbed with pure phenol, neutralized with alcohol; iodin in sinuses; no internal treatment; cured
1915	Carmody, T. E.*	Personal letter, St. Luke's Hospital, Denver	♀	24	Nurse	Montrose	Soft tissue of cheek, left side mandible	3 to 4 months	Temporomandibular articulation was affected; required operation for ankylosis; Lugol's solution administered; cured

R. W. Corwin of Colorado Fuel and Iron Co., Pueblo, reported two cases in their hospital several years ago, but no histories were kept.

* Had two Mayo Clinic cases.

MAYO CLINIC CASE

1921	Case 130	.....	♀	18	Stenographer	Cokedale	Right cheek and neck	3 years	Two years ago impacted third molar and several other teeth extracted; local doctor diagnosed actinomycosis; given two roentgen-ray treatments and increasing doses of potassium iodid; ankylosis first symptom; actinomyces found in pus from discharging sinus; radium and potassium iodid given

Year	Author	Source	Sex	Age	Occupation	Residence	Location of Lesion	Duration of Symptoms	Remarks
		Arizona							
		PUBLISHED CASE							
?	Powers, C.*	Personal communication to Ruhräh	♂	50	Cattle raiser	Arizona	Cheek and jaw	?	Ruhräh, Case 3; had slept on ground for years; histologic diagnosis
		MAYO CLINIC CASE							
1923	Case 131		♀	30	Wife of mining engineer	Inspiration	Lower abdomen, sinus	1 year	Marked improvement; potassium iodid, radium and roentgen-ray treatments
		New Mexico							
		PERSONAL LETTERS							
?	Dr. Worley, U. S. Pub. Health Service	Reported by Dr. Luckett, Public Health Bureau	♂	36	Farmer	San Patricio	?	?	?
1917	Vickers, F. D., Deming	Personal letter	♀	29	Grocery clerk	(Nebraska case, under Nebraska)			
		PACIFIC STATES							
		California							
		PUBLISHED CASES							
?	Cagliere, G. E.*	Pacific Rec. Med. & Surg., Dec. 15, 1898	♀	30	Housewife	California	Lungs	?	Ruhräh, Case 62; empyema; ribs resected; actinomyces found in pus; died
1893	Black, S. P.*	South. Calif. Pract., 1898	♂	32	.....	California	Lower jaw and neck	3 months	Ruhräh, Case 70
1897	Black, S. P.*	South. Calif. Pract., 1898	♀	?	Housewife	California	Abdomen	7 or 8 mos.	Ruhräh, Case 71
?	Ophüls, W.	J. M. Res. 8: 242-253, 1902	♂	37	?	California	Lungs	4 months	Necropsy: branching acid-fast bacilli in diseased areas; no growth of cultures
?	Ophüls, W.	J. M. Res. 8: 242-253, 1902	♂	70	Milkhand	California	Lungs	4 months	Necropsy: gangrenous area; branching, acid-fast organism; grew first generation on glycerin agar; no growth in transplants
?	Ophüls, W.	J. M. Res. 8: 242-253, 1902	♂	52	Laborer	California	Lungs	5 weeks	Acute; necropsy: gangrenous cavity in upper lobe of right lung; acid-fast branching organisms; no growth
?	Ophüls, W.	J. M. Res. 8: 242-253, 1902	♀	24	(Epileptic)	California	Lungs	Several years	Necropsy: similar to preceding case
?	Ophüls, W.	J. M. Res. 8: 242-253, 1902	♂	52	?	California	Lungs	5 days	Acute, following railroad accident
		PERSONAL LETTERS							
1916	Iglick, S.	Orland, Calif. (reply to letter, J. A. M. A.)	?	2	Child	Orland (now Crockett)	Scalp	3 months	Diagnosis by granules; played with domestic animals; cured with potassium iodid compresses and internal treatment
?	Woolsey, J. H.	University of California, San Francisco	♂	28	Dentist's assistant	Army, San Francisco Central Calif.	Mandible	3 years	Osteomyelitis of mandible; diagnosis from granules; died; necropsy showed extensive osteomyelitis
1919	Pritchard, W. F.	Thesis, Lane Med. Library, San Francisco	♂	38	Russian sailor	?	Jaw and subcutaneous, lung?	6 months	Resolving bronchopneumonia; actinomycosis of jaw and subcuticular tissue; nodules excised showed granules; cultures positive; sputum always negative, but bloody; definite roentgen-ray findings; huge doses of potassium iodid given

1921	Woolsey, J. H.	University of California, San Francisco	♂	28	Chemist	San Francisco	Subdiaphragmatic, hepatic, pulmonary	9 months	Yellow granules in discharge from sinus following appendectomy; died; necropsy revealed multiple actinomycotic abscesses throughout abdomen
1921	Frick, E. B.	San Francisco Hospital	♂	38	Sailor	?	General	14 months	Died; no necropsy; lesions of neck, trunk, abdomen and extremities, cutaneous and subcutaneous all yielded yellow granules
1921	Rinkenberger, F. W.	Los Angeles, reply to published request	♂	50	Physician	California	Right hip	5 months	Doctor had been treating case of actinomycosis; Zeller (?) cultured organism and made diagnosis from direct examination of granules
?	Loiseaux	Sacramento Hospital	♀	35	?	San Francisco	Abdomen following appendectomy	?	Ray fungus demonstrated (Dr. Twitchell)
	Loiseaux	Sacramento Hospital	♂	26	Grain handler	Sacramento	Right lower jaw	5 to 6 months	Roentgen-ray findings demonstrated loss of jaw (Dr. Swigart)
	Loiseaux	Sacramento Hospital	♀	40	Farmer's wife	Sacramento	Sublingual space	3 months	Granules in pus (Dr. A. M. Henderson)
					Oregon				
					PERSONAL LETTER				
1920	Crank, A. C.	Reply to letter in J. A. M. A.	♂	43	Farmer	Oregon	Jaw	8 or 9 months	Actinomyces in pus; findings verified by two other laboratories
					MAYO CLINIC CASE				
1917	Case 132		♂	58	Laborer	Pendleton	Right side of neck	2 months	Had trouble with right ear 2 months ago; lumps just behind lobe of the ear; grew 1 month; curetted, roentgen-ray treatment; actinomyces in pus
					Washington				
					PUBLISHED CASES				
1908	Varney, H. R.	J. Cutan. Dis. **27**: 235-237, 1909	♂	?	Section hand	Seattle	Jaw, cheek, neck, lung	1 year	Seen at Detroit; actinomyces in sputum
1918	Mattson, W. W.	Surg., Gynec. & Obst. **34**: 482-484, 1922	♂	26	Marine fireman	Washington	Right side of neck	1½ years	Worked in harvest fields; chewed grains; four teeth pulled; actinomyces in pus
1919	Mattson, W. W.	Surg., Gynec. & Obst. **34**: 482-494, 1922	♂	56	Manager of farmer's store	Washington	Lungs and bones	?	Twenty years before treated cow for lump jaw; 11 years before had appendectomy; 2 years before had ulcerated tooth extracted; chewed raw grain in store; actinomyces in sputum; Died within 6 months
	(Under Illinois and Kansas for cases by same author)								
					PERSONAL LETTERS				
	Demetria, M.	St. Joseph's Hospital, Tacoma	♂	32	Farmer	?	Left side of neck	?	Operated on; recovered
1920	Buckner, H. N.	Swedish Hospital, Seattle	♂	26	Custom officer	Washington	Neck	1 week?	Had been inspecting hides in hold of vessel week before; cured
1922	Crabtree, G. H., and Mason	King County Hospital, Seattle	♂	35	Stockyard, factory	Washington	Left side	6 months	Patient thought infection started in left tonsil; actinomycosis diagnosed by pathologist; died of carcinoma
					MAYO CLINIC CASES				
1917	Case 133		♂	22	Machinist	Bellingham	Phlegmon, left temporal region	6 months	One and one-half years previously had much trouble with teeth; draining sinus for 6 months; diagnosis, actinomycosis, made clinically
1921	Case 134		♂	61	Farmer	Tekoa	Left temporal region	5 months	Teeth extracted; sore jaw; pain in left temporal region; opened; actinomyces found in pus

THE RECONSTRUCTION OPERATION ON THE HIP

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The advance of operative technic in the last few years has been so satisfactory that relief from the disabling effects of various joint conditions by reconstruction operations has been meeting with increasing success. The number of joints amenable to reconstructive surgery is increasing, and the results are increasingly satisfactory. The value of reconstructive operations is especially evident when the operations are on joints whose functions involve weight bearing. In a few years, the surgical trend has changed from fixing a limb in a favorable attitude to mobilization, and, as a result, improved function. The present status of this work was made possible largely through the excellent work of such men as Putti, Baer and McAusland.

Until recently, we had little hope for successful arthroplasty or reconstructive operations on the hip. We have become more hopeful as regards function of the hip since Royal Whitman, in 1916, performed his first reconstruction operation on the hip. Originally, the operation was performed for nonunion following fracture of the neck of the femur. More recently, the operation has been performed in treating many severe disabilities of the hip joint. Some of the conditions for which the operation has been performed are ostearthritis, tuberculous disease, pathologic dislocation from pneumococcic and other infections with destruction of the femoral head and for pathologic fracture of the neck of the femur.

SELECTION OF CASES

The selection of proper cases for this operation is difficult. The following considerations are important:

1. Nonunion following fracture of the neck of the femur. The patient's general condition must be such that he shall, after a successful result, be able to enjoy the benefit of the operation. Incidentally, we desire to operate for disability rather than pain.

2. Cases of malum coxae senilis. Those cases in which only one joint is involved in the arthritic process are ideal for the reconstruction operation.

3. Should we operate when more than one joint is involved? If both hips are stiff, the disability is great. It is, therefore, advisable to mobilize one joint and, after full recovery, perhaps to attempt the other.

When many joints are involved, as in general or multiple arthritis, the relief or benefit gained by mobilizing one joint seems so small as not to warrant the reconstruction operation.

4. Pathologic dislocations of the hip should be reconstructed as soon as one is certain that all possibility of activating the original condition has ceased. The early return to more normal function is conducive to improvement in general health and in the local condition, by preventing atrophy and secondary deformities. In this group, the ideal cases for operation are those in which there is only a moderate degree of bone destruction, and in which the other joints of the body are in good condition.

5. It is generally unwise to attempt or to advise reconstruction operations when there is much destruction of soft tissues with resultant scarring following pyogenic or tuberculous infections. In such conditions, it is difficult for the muscles about the hip to function, and muscle function about the hip must be equal to the necessary work.

We aim to obtain, by the reconstruction operation, a stable, painless hip in a satisfactory attitude, i. e., one of extension and abduction. In cases of fracture of the neck of the femur with nonunion, the chief complaint is of painful disability. The patient has extreme difficulty in change of position, that is from the sitting to the erect posture, and vice versa; walking is difficult because of the adduction and flexion of the limb, pain and instability. The disability increases as time goes on, so that ultimately we see a patient past middle age walking with great difficulty and discomfort and compelled to use some form of support, such as a crutch. The reconstruction operation, by removing the head and remodeling the neck to fit into the acetabulum, relieves the instability. The operation is indicated early because of the tendency to early absorption of the femoral neck.

The cases of malum coxae senilis have symptoms because of the destructive process in the joint cartilage, usually limited to the head of the femur and the deformity of the hip. As a result of the hypertrophic condition often present, the head of the femur is, to a greater or less degree, subluxated or dislocated from the acetabulum. Benefit is derived here, as in the other types of the arthritides, by removing the diseased tissue.

In the group of pathologic dislocations, whether from tuberculous disease or other infectious processes, the symptoms are deformity and disability; the extent of these symptoms depends on the degree of destruction and the amount of telescoping of the remains of the head and neck into the soft tissues on the dorsum of the ilium. The operation attains its end by remodeling the upper extremity of the femur, deepening the acetabulum, reducing the dislocation and correcting the deformity.

TECHNIC OF OPERATION

The technic of the reconstruction operation varies somewhat, depending on the condition for which it is being performed. The technic for fracture of the neck of the femur with nonunion is as follows:

The patient is given a very careful preparation of the hip from the rib line to below the knee. Two days before operation, the part is shaved, washed with green soap, water, ether and alcohol, and a sterile dressing is applied. The day before the operation, this procedure is repeated, except that the part is not shaved. The morning of the operation, 3.5 per cent. tincture of iodin is applied, and, when dry, a sterile dressing is put on. No catharsis or enemas are given unless the patient's bowels do not evacuate. If necessary, a low enema is given the morning of operation. For a week before operation, to prevent postoperative acidosis, the patient is given an added diet of forced fluids, plenty of sweets and sodium bicarbonate three times a day. A light breakfast is allowed the morning of operation, and, if the operation is to be at 3, tea and toast or milk is allowed at 10:30 or 11 a. m.

A half "U" skin incision is made on the lateral aspect of the hip, beginning 1 inch (2.5 cm.) below and behind the anterior superior spine and extending down in a vertical plane to a point 3 inches (7.6 cm.) below the level of the tip of the trochanter; it then curves across to the outer posterior aspect of the thigh, behind the great trochanter. This incision is made through the skin and fat. A similar incision is made through the fascia, which fascial flap may later be used for a transplant over the newly formed head, or to line the acetabulum. This entire flap is dissected back, exposing the greater trochanter. The joint is exposed by blunt dissection through the intermuscular plane between the gluteus medius, which is retracted posteriorly, and the tensor fascia femoris, which is retracted anteriorly. With a broad chisel, the great trochanter is removed at its base from the femur and retracted up, together with its attached pelvitrochanteric muscles. This leaves an enlarged neck for a weight bearing surface, to be placed in the acetabulum. The capsule is incised at its lower attachment and along the upper surface of the femoral neck to the acetabulum, and lifted with a periosteal elevator, so that the head of the femur and the rim of the acetabulum are brought into view. With the aid of the Putti chisel and by flexing, adducting and externally rotating the hip, the head of the femur is dislocated from the acetabulum. The fractured head, usually united to the neck by fibrous tissue, is now removed. The neck is smoothed with chisel and rasp. The acetabulum is cleaned of any fibrous tissue with a curet and Doyen instrument.

An area of bone on the outer aspect of the shaft below the original site of the great tronchanter is freshened with a chisel, the periosteum

having first been elevated. The wound is flushed with hot saline solution and bleeding is controlled. The reconstructed head or neck is replaced in the acetabulum with the aid of a "shoe horn," and the limb is abducted. The trochanter is drawn down and apposed to the freshened bone prepared for it, and secured with kangaroo tendon sutures. The wound is closed in layers. A long plaster-of-Paris spica bandage is applied, extending from the internipple line to the toes, with the hip in the attitude of full extension and 20 degrees or more of abduction. It is advisable to flex slightly the knee and put the foot at right angles to the leg. The patient is returned to bed, and, when he has recovered from the anesthetic and his condition is favorable, the head of the bed is elevated.

The operation on the arthritic hips differs from that just described in that only the diseased tissue is removed from the head and neck of the femur and the acetabulum. The head is reduced about one-half in size, the acetabulum deepened with the Doyen instrument and all diseased tissue removed therefrom. There is often ankylosis in this condition, necessitating the separation of the head of the femur from the acetabulum. This is done with the Putti chisel. Care should be taken to follow the outline of the acetabulum, as it is usually hard, whereas the head is usually atrophied and soft. Care is thus exercised not to fracture the femoral head.

The operation for pathologic dislocation should be preceded by preliminary traction, especially if the telescoping of the remains of the head or neck has been considerable. We found that, in one case in this series, the reconstructed part was placed in a secondary acetabulum. Preliminary traction makes the reduction easier, thus decreasing the time of the operation, its mechanical difficulties, the postoperative shock and the ultimate tendency to recurrence of the deformity. Tuberculous hips usually present similar problems, although one must change minor details more frequently than in other conditions for which the reconstruction operation is performed. The reason for this is the extensive destruction of tissues, the presence of scar tissue and old sinuses, and, often, pathologic dislocation. For example, if the head and neck of the femur are entirely destroyed, one must be contented with a small head and neck for the newly constructed hip joint, which must be placed in contact with the upper part of the acetabulum. Furthermore, if the new neck of the femur is very short, the limb should be put up in only moderate abduction, not over 15 or 20 degrees, or the patient will not be able to walk well.

Conditions of the hip for which the reconstruction operation is performed are practically always seen in the attitude of deformity, viz., flexion and adduction of the hip. When the deformity is marked, it is

advisable to do the operation in two stages—preliminary stretchings or tenotomies at the first stage and the reconstruction operation about ten days later. This is especially important in the class of the infectious arthritides and the tuberculous joints, also to determine if the infection has been eradicated or is only latent. The preliminary stretching decreases the tendency to a return of the deformity postoperatively and also makes postoperative manipulations easier.

POSTOPERATIVE CARE

Cases other than pathologic dislocation usually remain in plaster from three to four weeks. The plaster is then removed, and the patient remains in bed with the limbs in abduction. Voluntary motion in the knee and hip is encouraged within the limits of pain. After a few days, a swinging apparatus is applied, holding the limb suspended in a Thomas splint from a Balkan frame and so arranged as to permit motion in the hip, ankle and knee. This apparatus is used for about three weeks. The patient may walk with crutches in from six to eight weeks and bear weight as soon as it is comfortable to do so, which is usually in about eight weeks. Convalescence naturally varies with the individual patient. The patients begin walking with the use of two crutches. Several weeks later, one crutch is discarded, then the other, and the patient uses a cane or no support. About six months from the time of operation, the patient usually walks well and is able to work. Pathologic dislocations and others in which there is destruction of the head and most of the neck, necessitate the maintenance of the abduction treatment to prevent dislocation for a much longer time, or until the new attitude is maintained by firm adhesions. This requires holding the limb in plaster in the abducted attitude from three to six months. In these cases, at the end of three or four weeks, a short spica is applied, and the patient permitted to walk with crutches.

Maintenance of the attitude of extension and abduction is the most important factor in the after-care. The patient and a friend are instructed in the procedure of stretching the limb. The patient, or some one else, holds the pelvis steady. Another grasps the foot, applying traction and swaying the limb gradually into increasing abduction. The patient then turns face downward. With one hand placed under the thigh, just above the knee, and the other hand on the buttock to hold it securely on the bed, the thigh is forcibly raised. This is repeated. The continuous practice of this will prevent a recurrence of the deformity, and the result of the operation will be a painless, stable joint with a crutchlike limb in good attitude. Physiotherapy is also a valuable adjunct in the postoperative treatment.

There is often marked atrophy in the disabled limb, most of which is due to disuse. This is corrected to a marked degree by the operation which permits proper function of the part. This is also an argument for early operation.

THIRTY-SIX OPERATIONS

Thirty-six operations are herewith reported, performed on thirty-four patients, both hips being operated, in one case, and two operations on one hip, in another case. The patients in the report were operated on between December, 1921, and December, 1923. Twenty-five of the patients were operated on in 1923. Fascial grafts were used, in four cases of arthritis, and the graft was extruded, in one case. Four of the patients (11.9 per cent.) died. One patient died from shock a few hours after the operation for fracture with nonunion. This patient was in bed for fifteen months before the operation. Two deaths were probably due to emboli; one occurred the day of the operation, the operation being performed for fracture of the neck of the right femur with nonunion; the other occurred four days after operation for ostearthritis of the left hip. The fourth death was the result of metastasis from a sarcoma present in the hip, at the time of operation, and on the breast, previously. The patient died of exhaustion six months after the reconstruction of the hip. A necropsy was not obtained in any case.

Two patients of those with tuberculous disease had sinuses after the operation. The disease in one had been symptomless for about one year, and this patient had had no previous sinuses. In the other, there were no symptoms for nine years, but the patient had had previous sinuses.

Four of the patients suffered from complicating emboli. Two of these died (reported above). The other two were both operated on for ostearthritis of the hip; one on the right side, and the other on the left side. Both developed bronchopneumonia; both recovered. The embolism occurred two weeks after operation, in one case, and six weeks after operation, in the other.

In ten cases, the operation was performed for fracture of the neck of the femur with nonunion. Of these cases, the youngest patient was 39, the oldest 70. The shortest time between the fracture and the operation was two months, the longest eleven years. Nine of the patients were female, one male. The fracture was on the right side in six cases and on the left in four.

In eight cases of the arthritides, there was involvement of one joint (malum coxae senilis). The youngest patient was 21, the oldest 60. Two patients were males, six females. It is of interest, in this connection, to refer to a statement by Whitman.[1] "It is far more common

1. Whitman, Royal: Orthopedic Surgery, Ed. 6, p. 384.

in males than in females," whereas, in this series, the opposite is the case. In regard to the duration of symptoms, in one case they were of one year's standing, while in another of thirty years. Two cases of embolism occurred in this group; both patients recovered. Fascial grafts were used in three cases, and the graft was extruded in one.

In a group of five cases, more than one joint was involved in the arthritic process. In three cases, both hips were involved; in one case, both knees and hips were involved. In the latter case, the reconstruction operation was performed on both hips. The youngest patient in this group was 16, the oldest 56; there were one male and four females. The earliest symptoms were noted, in one case, ten years before operation, and, in the most recent case, five years. One patient died four days after the operation from embolism. In one case, fascial transplant was used.

The reconstruction operation was performed in six cases with tuberculous hips. The patients were all males. The right hip was involved in two cases, the left hip in four. The youngest boy in this series was fourteen; his symptoms of tuberculous disease were noted six years before operation. The oldest patient, a man of 42, had symptoms noted thirty-three years before operation. One patient in this series had been symptomless one year. The longest symptomless period was twenty-six years.

In three cases, the patients were operated on for pathologic dislocation following an infectious process other than tuberculous disease. The etiology was unknown in one case, and followed pneumonia in the other two. The youngest patient was 5, the oldest 13; all were females. The right hip was involved in two cases, the left in one. The infectious process was quiescent for four years in one case, and for ten years in the other two.

One case of metastatic sarcoma of the hip with pathologic fracture of the neck of the femur is included in this series. This patient, a man of 50, with the right hip involved, had metastasis from a sarcoma of the breast which had previously been amputated.

In a case of Charcot hip with pathologic fracture of the neck of the left femur in a man of 30 who had syphilis eleven years before, an operation was performed. This patient referred his symptoms to the hip for only three weeks.

Of the thirty-four patients, six were in the hospital at the time of the writing of this paper.

REPORT OF CASES

GROUP I. FRACTURE OF NECK OF FEMUR WITH NONUNION

CASE 1.—A woman, aged 59, whose history was unobtainable, underwent, May 28, 1923, the usual reconstruction operation on the right hip. The wound healed by primary union. Roentgen-ray examination showed the stump of the neck firmly in place and in good position in the acetabulum.

June 28, the plaster was removed, and a swinging appliance was put up. July 24, the patient was out of bed and walking with the aid of crutches. October 20, the patient walked well, using one crutch. She is now able to walk without support; there is no pain; she is doing her own housework. and is very well pleased with her condition.

CASE 2.—G. P., a man, aged 58, had received a fracture fourteen months before operation. June 28, 1923, the usual reconstruction operation on the right hip was done, modified in that the cancellous tissue was reamed from the head and the newly formed and freshened neck was forced into the shell of cartilage of the head. The wound healed by primary union. There was no shock and only slight postoperative discomfort.

July 30, the plaster was removed, and the patient was comfortable; the limb was manipulated at least twice daily into abduction and extension. August 4, the patient was in a wheel chair the greater part of each day. September 1, the patient was walking with the aid of crutches. The limb was in a satisfactory attitude and there was only slight discomfort on weight bearing.

CASE 3.—A. I., a woman, aged 56, had received a fracture six years before operation, and there was 3 inches (7.6 cm.) of shortening. Roentgen-ray examination showed almost complete absorption of the neck and partial absorption of the head. December 1, 1923, the usual reconstruction operation was performed on the right hip. The head of the bone was removed piecemeal because of adhesions holding it in the acetabulum. The limb was put up in 30 degrees abduction and in internal rotation.

December 28, the plaster was removed. The wound had healed and roentgen-ray examination showed the position to be good. The highest temperature was 100.6. The patient's general condition was excellent. The patient is still in the hospital.

CASE 4.—S. W., a woman, aged 70, had an untreated fracture of two months' duration. Roentgen-ray examination showed absorption of the neck with no attempt at union; the great trochanter was elevated and the limb rotated outward. March 8, 1923, the usual reconstruction operation was performed on the right hip. At 9 p. m., the patient suddenly developed respiratory embarrassment, pain in the upper part of the left side of the chest and the left shoulder, and the pulse was rapid and thready. March 9, the pulse was 130; respiration was 48, temperature was 103. The patient died at 10:45 a. m. The diagnosis was pulmonary embolism.

CASE 5.—H. B., a woman, aged 50, had received a fracture of the neck of the femur twenty months before admission. She had never been free from pain. The patient walked with the aid of crutches, and the limb was in an attitude of outward rotation, flexion and persistent adduction of 10 degrees. The trochanter was elevated; there was 1½ inches (3.7 cm.) of shortening, and roentgen-ray examination showed complete absorption of the neck, with possibly some union. October 1, 1923, under ether anesthesia, the Whitman abduction treatment for fracture of the neck of the femur was carried out to determine if union was present. Roentgenograms showed relation of the shaft of the femur and the head. In comparison with roentgenograms taken before operation, they showed the condition very much changed, indicating nonunion. The plaster was therefore removed, and, October 22, the usual reconstruction operation was performed. A mass of granulation tissue was found beneath the head of the bone in the acetabulum, probably causing the pain. The line of fracture corresponded to the epiphyseal fracture seen in

childhood. There was some union at the posterior aspect of the neck evidenced by the somewhat difficult separation of the head and neck in this region.

November 16, the plaster was removed and a swing was applied. Movements of the hip were very sensitive, and the patient also complained of considerable pain in the knee. January 26, the patient was walking with the aid of one crutch. There is now only slight discomfort in the knee; she is able to walk up stairs, and considers her condition much improved.

CASE 6.—A. P., a woman, aged 44, had received a fracture two months before admission, which had been untreated. There was loss of weight from 112 to 90 pounds (50.8 to 40.8 kg.). The patient walked with the aid of crutches, and had persistent pain in the right hip. Roentgen-ray examination showed absorption of the neck, and that the trochanter minor was opposite the lower border of the acetabulum. November 6, 1922, the usual reconstruction operation was done. Three days later, because of her mental condition, the patient was transferred to a psychopathic hospital. The patient is still in the hospital (condition unknown).

CASE 7.—F. F., a woman, aged 39, had a fracture of one year's duration, which had been treated by the abduction method. The patient was in plaster for twelve weeks. Since that time, she had been walking with the aid of a crutch and a cane. The patient limped and suffered pain in the hip. Roentgenograms taken at the time of injury showed an intracapsular fracture, the neck at right angles with the shaft, and an upward displacement of the trochanter. Roentgenograms, taken on admission, showed the same relative position. March 26, 1923, the Whitman abduction treatment for old fracture of the neck of the left femur was given. Traction did not reduce the shortening, showing that there was some union.

June 2, the plaster was removed. Roentgenograms showed fair approximation of the fragments, the outer being above the inner. It was evident that there was only fibrous union. June 18, the reconstruction operation was performed. The patient had immediate, severe shock; the pulse was imperceptible; the extremities were cold, and there was slight cyanosis. The patient did not respond to stimulation and died of shock.

CASE 8.—H. M., a woman, aged 50, had a fracture of eleven years' duration. Roentgen-ray examination showed an old fracture of the neck of the left femur with malunion and a partial dislocation or arthritic process of the head of the femur. On account of the pain and limp, it was assumed that the union was undoubtedly fibrous. Nov. 2, 1923, the usual reconstruction operation was done. The wound healed by primary union, and the convalescence was uneventful.

November 28, the plaster was removed. Roentgen-ray examination showed the neck in the acetabulum. Jan. 15, 1924, the patient was walking with the aid of one crutch. The limb was in a satisfactory attitude; there was no pain, and only slight discomfort in the operated area on weight bearing. The patient is still in the hospital.

CASE 9.—L. S., a woman, aged 50, had received a fracture of the left hip 2½ years before admission. The patient's general condition was good. Roentgen-ray examination showed an intracapsular fracture with nonunion. July 2, 1923, the usual reconstruction operation was done. The wound healed by primary union. The patient was in plaster for three weeks, and in the swinging apparatus for three weeks.

November 25, the patient walked well with the aid of one crutch. There was no pain; motion in the hip was maintained, and the limb was in a satisfactory attitude.

CASE 10.—M. H., a woman, aged 52, had a fracture seven months old. The patient walked with difficulty with the aid of two canes. March 29, 1923, the usual reconstruction operation was performed.

May 7, 1923, the plaster was removed. Four days later, the patient was walking very well with the aid of crutches. The discomfort was slight, and the limb in a satisfactory attitude. The patient was discharged.

GROUP II. MALUM COXAE SENILIS

CASE 11.—K. C., a woman, aged 45, following the birth of a child, four years before admission, had pain in the right hip and limped. The pain persisted and gradually increased in severity. July 9, 1923, the reconstruction operation for ostearthritis of the hip was performed. The entire head of the femur was removed. July 24, the patient suddenly complained of severe pain in the chest and expectorated some blood tinged sputum. She was pale and chilly, then slightly cyanotic and dyspneic, and had a rapid, feeble pulse. The diagnosis was pulmonary embolism. July 28, the condition in the chest was diagnosed as a low grade bronchial pneumonia, from which the patient made a complete recovery.

November 25, the patient was using one crutch but could walk without support. The limb was in a satisfactory attitude. The patient was able to do her own housework, and was well satisfied with her condition.

CASE 12.—M. M., a man, aged 55, had complained of increasing pain, weakness and limp of the right hip for five years. Nov. 21, 1923, the usual reconstruction operation on the right hip was performed, excepting that the tensor fascia femoris muscle was included in the incision. The reconstructed head of the bone was covered with fascia.

December 17, the plaster was removed, and the wound had healed. December 24, the fascia sloughed out. Jan. 10, 1924, the patient was discharged, and was walking with the aid of crutches. There was no discomfort, and the limb was in a satisfactory attitude.

CASE 13.—L. C., a woman, aged 57, following an attack of grippe, five years before admission, had suffered pain and discomfort in the left hip, a limp and increasing disability. All motions were restricted; rotation by one half, flexion to 90 degrees, and extension to 160 degrees. Dec. 31, 1923, the reconstruction operation was performed. The patient suffered considerable pain.

Jan. 2, 1924, the patient's temperature rose to 102 F., due to an infected hematoma. The entire wound was opened. Two days later, the temperature was normal. The patient complained of considerable pain in the chest, with dyspnea, cyanosis, slightly blood tinted sputum and an increased pulse rate, the symptoms suggesting a mild degree of embolism. She was still in the hospital.

CASE 14.—P. S., a man, aged 60, a chauffeur, complained of stiffness and pain in the left hip, the pain being more severe when he rose in the morning. Flexion of the left hip was possible to 100 degrees and extension to 160 degrees; abduction and rotation were entirely limited. The trochanter was prominent and slightly elevated; there was one-half inch (1.27 cm.) shortening. Nov. 20, 1922, the usual reconstruction operation was performed.

Nov. 25, 1923, the patient was able to walk 5 miles. He had resumed his duties as a chauffeur. He could walk without a cane and the attitude of the limb was satisfactory.

Case 15.—T. M., a woman, aged 48, had been limping for twelve years, and had suffered pain in the hip as far back as she could remember—at least thirty or thirty-five years. She walked with difficulty, using a cane. The limb was flexed to 135 degrees, and adducted 15 degrees, with only 10 degrees of motion. The atrophy was marked; the actual shortening was 1¼ inches (3.1 cm.), the apparent shortening 2 inches (5 cm.). The atrophy of the thigh was 4½ inches (11.4 cm.). Roentgen-ray examination showed an upward tilting of the pelvis on the affected side; the spine deviated to the opposite side of the deformity, and there was flattening and moderate absorption of the head.

Nov. 12, 1923, the reconstruction operation was performed. The highest temperature was 101 F., the pulse 100. The temperature was normal in seven days.

December 15, four weeks after the operation, the plaster was removed, and, as the discomfort was slight, the swinging apparatus was not employed. There was passive abduction to 25 degrees, flexion to 150 degrees. December 18, the patient suddenly developed symptoms of embolism while the leg was being massaged, and then developed bronchial pneumonia at the base of the right lung. The recovery was rapid. Jan. 16, 1924, the patient was discharged, walking with the aid of two crutches. The position of the limb was satisfactory.

Case 16.—J. W., a woman, had a painful left hip with a limp and increasing disability for eight years. Roentgen-ray examination showed a marked irregularity and superficial destruction of the head of the femur. April 9, 1923, the usual reconstruction operation for ostearthritis was performed.

May 27, the patient was discharged, walking with the aid of crutches. There was no pain; the limb could be flexed to 80 degrees; extension was normal; there was abduction to 30 degrees, and rotation was three-fourths normal. Manipulation and massage were to be continued for several months, and the patient was to report monthly for supervision over a period of one year. The condition was improved.

Case 17.—C. D., a woman, aged 21, sustained a slight injury to the left hip eight years before admission. She was well for six weeks and then complained of a slight pain in the left hip. She was treated with plaster for four months, but she had a limp and stiffness of the hip, which persisted with increasing disability. Dec. 19, 1921, the usual reconstruction operation was done. A fascial graft was used to cover the head. The adductor longus muscle was divided in order that the adduction could be overcome.

Jan. 22, 1922, the plaster was removed; the wound had healed by primary union. March 6, the patient was discharged. He was walking with crutches; the limb was abducted to 20 degrees, and flexion was possible to 150 degrees.

Case 18.—C. D., a woman, aged 33, fifteen months before admission, had fever, followed by pain in the left hip and increasing disability. The hip was ankylosed in an attitude of slight flexion and adduction. Roentgen-ray examination showed a destruction of the head of the femur and an upward displacement of the acetabulum; the limb was adducted 10 degrees and flexed 140 degrees. Oct. 23, 1922, the leg was forcibly extended and abducted, and a long plaster spica was applied. December 8, a short spica was applied, and the patient was discharged, walking with crutches. The patient was

instructed to return in three weeks. Jan. 22, 1923, the reconstruction operation was performed, with a fascial graft to cover the head of the femur. The convalescence was uneventful.

February 9, the plaster was removed and a swinging apparatus was applied. March 3, the patient was able to walk well with one crutch, but could do without it or use a cane. She complained of slight pain in the left hip on pressure through the foot. March 22, the patient was discharged. In June, the extension was complete; the patient could flex to 150 degrees, abduct 15 degrees and adduct 5 degrees. Internal rotation was less than half normal.

GROUP III. CASES OF POLYARTHRITIS

CASE 19.—J. G., a woman, aged 29, had both hips and both knees involved. The involvement in the right hip had been insidious in onset six years before, following an operation on the uterus. The patient gave the usual history of difficulty in arising from the chair. The knee was flexed to 170 degrees, and was slightly painful. The hip could be extended to 150 degrees, flexed to 140, and was adducted 10 degrees. Abduction and rotation were entirely restricted, and all motions were painful. June 16, 1923, the usual reconstruction operation on the right hip was performed. Convalescence was uneventful, except for a subacute sinusitis.

August 16, 1923, the patient was discharged. There were 20 degrees abduction and a few degrees of rotation. The patient walked with crutches, and complained of considerable pain and discomfort on weight bearing. She found it extremely difficult to get about, and the other joints of the lower extremities also were painful. In January, 1924, the limb was in extension and slight adduction. The patient was disinclined to help herself; she spent most of her time in bed; her general condition was only fair, and she complained of considerable pain on motion in the hip that had been operated on, but even more in the other joints of the lower extremities. The condition was unimproved.

CASE 20.—L. M., a girl, aged 16 years, with both hips involved, had had pain for six years. Her general condition was good, but she walked awkwardly; the position was distorted, and there was extreme lordosis, due to the deformity of the left lower extremity. The pelvis was tilted to the left; the left thigh was flexed and fixed in right angular relation to the pelvis and abducted 15 degrees, and the trochanter was on a level with the tuberischii. There was apparently bony ankylosis. On the right side, the trochanter was above Nélaton's line. The limb was in an attitude of 130 degrees extension, 90 degrees flexion, and 10 degrees adduction. Roentgen-ray examination of the left hip showed complete bony ankylosis with partial destruction of the head and neck, and the acetabulum was not visible. Roentgen-ray examination of the right hip showed the acetabulum to be irregular and enlarged upward, the head of the femur being irregular, evidently the result of disease. April 24, 1922, the usual reconstruction operation was performed.

May 27, the plaster was removed. There was no discomfort. Traction was applied. The wound healed by primary union. There were a few degrees of painless motion. October 7, the right hip was flexed to 165 degrees, and was adducted 10 degrees. There were a few degrees of motion. Under an anesthetic, the limb was completely extended and abducted 20 degrees. The limb could be flexed to 90 degrees, but a slight creeking motion was heard and felt. A plaster-of-Paris spica was applied and left on for six weeks.

November 21, the patient suddenly cried out with terrific pain, referred to the region of the spine, between the eighth and the twelfth dorsal vertebrae. The pulse was 140, weak and running; respiration was 36. The patient was pale, slightly cyanotic, dyspneic and chilly. In five days, the patient apparently recovered from what was undoubtedly an attack of embolism. December 14, a swing apparatus was applied for exercising the right lower extremity. Jan. 20, 1923, a roentgen-ray examination of the right hip showed the dislocation reduced. There were a few degrees of motion. June 9, the patient was walking with crutches, and there was no pain. The right hip was ankylosed in full extension and 15 degrees abduction; the left hip was ankylosed in 20 degrees adduction. The patient was ordered to return later if she desired further correction of the deformity. She was satisfied with her condition, as it was a marked improvement over her deformities when admitted.

CASE 21.—M. R., a woman, aged 56, had an involvement of the hip caused by a fall, ten years before admission. One and a half years before the patient came for treatment, the left hip became involved, with pain, increasing stiffness and disability. At 18, the patient had acute articular rheumatism. The right hip was adducted and flexed to 150 degrees; there were a few degrees of painful motion. The left hip could be extended to 150 and flexed to 125 degrees. All other motions were restricted. Oct 2, 1922, the usual reconstruction operation was performed on the left hip.

October 6, the patient suddenly developed severe pain in the interscapular region, dyspnea, restlessness and slight cyanosis, and died within twenty-four hours. It is the opinion of the operating surgeon that the patient died of pulmonary embolism.

CASE 22.—R. W., a woman, aged 55, had had pain in both hips for six years. The pain was worse in the left hip, with stiffness, limp and increasing disability. The condition was at no time acute, but all symptoms had become exaggerated in the last three years. March 5, 1923, the reconstruction operation was performed on the left hip. The acetabulum was found to be lined with healthy cartilage; the limb was placed in 30 degrees abduction. The right limb was easily completely extended and abducted to 30 degrees, accompanied by slight creaking.

March 21, 1923, the plaster was removed. The wound had healed by primary union. Jan. 18, 1924, the left hip could be extended to 170 and flexed to 145 degrees. There were 5 degrees of abduction and a few degrees of rotation.

CASE 23.—G. H. S., a man, aged 45, had been well until five years before admission, when he suffered an insidious onset of disease involving both hips, knees and the left elbow. Examination revealed that the general condition was good. The patient walked with a marked double limp, with the aid of crutches, and there was evident ankylosis of both hips and flexion contraction at the knees and hips. Oct. 31, 1921, the right hip reconstruction operation with fascial graft was performed. The trochanter was displaced and held in its new position by a bone screw. It was impossible entirely to overcome the adduction.

November 28, the plaster was removed, and the wound found clean. There were 25 degrees of free motion in all directions. Roentgen-ray examination showed the head much reduced in size in the acetabulum. December 24, there were 10 degrees of passive motion in all directions. The patient was bearing weight on the extremity which was in a good attitude. Clinically, the hip was stable. Feb. 13, 1922, the reconstruction operation on the left hip was

performed. In five days, the temperature rose to 105; there was a moderate gaping of the wound with a moderate amount of serous discharge, culture of which showed *Staphylococcus aureus.*

February 28, the plaster was removed. March 21, a secondary suture of the wound was made with good union. April 13, in the left hip there was 15 degrees abduction and extension to 160 degrees. August 27, the patient was discharged, walking with the aid of crutches, and was able to bear weight without discomfort. The position of the limbs was satisfactory, and there was relief from pain in the hips.

GROUP IV. PATHOLOGIC DISLOCATIONS

Following Tuberculous Disease.—CASE 24.—S. B., a boy, aged 14 years, had been treated conservatively for disease of the left hip for six years. Dec. 27, 1921, the general condition was good. The patient walked with a left limp and on the toes of the left foot. There were scars of old sinuses. The trochanter was above Nélaton's line. The limb was flexed to 100 degrees and adducted 15 degrees and there was 1¾ inches (4.3 cm.) shortening. Feb. 20, 1922, the reconstruction operation was performed, allowing the limb to be easily extended and abducted 25 degrees. March 12, the patient was out of bed in the plaster; the temperature was normal, and there was no pain. May 13, the patient walked well; his general condition was good, and the deformity was corrected.

CASE 25.—B. S., a boy, aged 16, gave as his history that following measles at 2½ years of age, he had had tuberculous disease of the left hip. The patient was apparently cured of the original disease, but returned because of the deformity. There was a flexion and adduction contraction at the left hip. Oct. 22, 1923, the usual reconstruction operation was performed. The patient was in bed for one month, then was out of bed in the plaster and walking with the aid of crutches. December 18, the patient was discharged, walking without crutches.

CASE 26.—W. K., a boy, aged 12, had had hip disease since he was 4 years old. He never had a sinus, and the condition had been untreated for the last year. The general condition was good. There was inward rotation of the left lower extremity; the trochanter was above Nélaton's line. The limb was ankylosed in 140 degrees of flexion and 15 degrees of adduction. Sept. 17, 1923, a reconstruction operation with a fascial lata graft over the head was performed. Jan. 7, 1924, the patient was able to walk with the aid of crutches and could bear weight without discomfort.

CASE 27.—R. G., a man, aged 24, had had disease of the right hip at 2 years of age. Examination revealed that the right hip was ankylosed; the head of the bone was destroyed. The trochanter and the shaft were displaced upward and ankylosed about 3 inches (7.6 cm.) above the acetabulum to the side of the pelvis. Oct. 8, 1923, a modified reconstruction operation was performed. An osteotomy of the femur was done opposite the acetabulum which was reamed out, and the extremity of the femur was placed therein with the limb in complete extension and 25 degrees of abduction.

Feb. 1, 1924, the attitude of the limb was satisfactory. It was fixed in extension and abduction. The patient was still in hospital.

CASE 28.—H. L., a man, aged 42, had been well until the age of 9 years, when he had disease of the right hip. The patient presented an old, healed tuberculous hip. He had pain and disability due to the telescoping of a pathologically dislocated hip. The patient walked with a right limp, and the

right foot was in equinus. The hip extended to 130, flexed to 80 and was adducted 15 degrees; abduction was entirely restricted. There was 3¼ inches (8.2 cm.) shortening. Feb. 6, 1922, a reconstruction operation was performed.

March 10, 1923, the patient was comfortable and was able to walk with ease. There were 15 degrees of motion in all directions, 40 degrees flexion, and the hip extended to 170 degrees.

CASE 29.—I. L., a boy, aged 16 years, had had disease of the left hip since the age of 5. Examination showed that the patient was in fair condition; he walked with difficulty with a marked left limp, and on the toes of the left foot. There was a marked increase in the lumbar curve, and there were numerous scars about the hip. The trochanter was prominent and above Nélaton's line; the limb was fixed in 120 degrees flexion and 5 degrees adduction, and was rotated internally. Roentgen-ray examination showed great atrophy of the femur, with complete destruction of the head and a portion of the neck, and destruction and obliteration of the acetabulum. April 2, 1923, the reconstruction operation was performed. The neck had a worm-eaten appearance and contained some cheesy material.

May 24, in changing the plaster, the insecure reconstructed neck was dislocated from the acetabulum. Under an anesthetic, the left limb was stretched to complete extension and abduction, and the dislocation reduced. Jan. 7, 1924, the patient no longer wore plaster, and was able to walk with the aid of a cane. The limb was in a satisfactory attitude.

Following Acute Epiphysitis.—CASE 30.—A. B., a girl, aged 10 years, at 1 month of age, had an acute epiphysitis of the right hip which was drained and healed. Examination showed that the patient was in good condition. She walked with a marked right limp, with the body inclined to the right and an abnormal lordosis. There was well marked pathologic dislocation. Movements were free except abduction, and there was 2 inches (5 cm.) shortening. May 22, 1923, a reconstruction operation was performed.

June 2, the patient was in plaster, and was able to walk with the aid of crutches. July 12, the patient was discharged, wearing a short spica. The limb was in a satisfactory attitude; the patient had no pain, and her general condition was excellent.

CASE 31.—L. F., a girl, aged 13 years, had had pneumonia at 3, complicated by an acute epiphysitis of the right hip which was twice incised and drained. She had been in bed for four months, when the part healed and remained healed. The patient's general condition was good. She walked with a marked right limp, and there were scars about the hip of old sinuses and incisions. The hip was adducted, extended to 150 and flexed to 100 degrees. There was destruction of the head and 2½ inches (6.27 cm.) shortening. June 25, 1923, the reconstruction operation was performed.

November 1, the patient had no pain and was able to walk without support. She had not been wearing plaster for some time.

CASE 32.—M. P., a girl, aged 5 years, had had bronchopneumonia at the age of 8 months, with numerous relapses and multiple abscesses about the body, the worst in the region of the left hip, which was drained. She walked at the age of 2, with deformity of the hip and limp. The child presented a dislocation of the hip from prior disease. There was 1½ inches (3.77 cm.) shortening. April 2, 1923, a closed reduction of the dislocated hip was attempted but was unsuccessful. April 16, a reconstruction operation was performed. Marked telescoping of the upper end of the femur was noticed. A roentgen-

ray examination showed the hip in a secondary acetabulum. June 29, reoperation of the same hip was performed by the Smith-Peterson approach. The old acetabulum was located and reamed out, and the reconstructed extremity was reduced therein.

August 22, new plaster was applied, and the patient was discharged. In January, 1924, the limb was in a satisfactory attitude; the patient walked without support, and her general condition was excellent.

GROUP V. PATHOLOGIC FRACTURES OF THE NECK OF THE FEMUR

Following Charcot Joint.—CASE 33.—M. S., a man, aged 30, had had syphilis when 11 years of age. The blood Wassermann reaction had been negative. The spinal Wassermann reaction had been positive at one time. He had been apparently well until three weeks before admission, when he had slight pain and swelling in the area over the neck of the femur. He walked with a limp, with a sensation of a springlike gait until three days before admission, when suddenly the sense of the springlike gait was lost. He heard a snap, and was unable to bear weight on the extremity. Examination, with the patient reclining showed that all motions of the hip were limited. Roentgen-ray examination showed a fracture of the neck of the femur, with the head smaller than normal, and an elevation of the trochanter. The knee jerks were absent. The pupils reacted sluggishly to light. Dec. 28, 1923, a reconstruction operation was performed. Convalescence was uneventful. The patient is still in the hospital.

Following Metastatic Sarcoma.—CASE 34.—B. S., a man, aged 50, had had symptoms of pain and discomfort in the right lower extremity ascending to the hips, with increasing severity, during the last eight months. Previously, the patient's breast had been amputated by Dr. Berg of New York for a spindle cell sarcoma. Examination of the patient, in bed, showed that the right lower extremity was flexed and adducted; motions were free but painful; extension was limited, and there was no infiltration or thickening. Roentgen-ray examination showed a fracture of the neck of the femur, also a haziness of the great trochanter, and the head and neck of the femur mottled. There was no evidence of metastasis elsewhere in the body. There was no history of trauma. March 13, 1922, a reconstruction operation with excision of the tumor tissue was done. All the tumor tissue could not be removed.

May 4, the patient walked with the aid of crutches. For a while the patient improved, but, within six months, he had a local metastasis and died of exhaustion.

SUMMARY

The patients described have not been operated on sufficiently long for final conclusions to be drawn. The paper is written to detail the principle of the treatment, which, if correct, needs no substantiation by end-results of cases. The results of the cases included are based on correction of the deformity, viz., placing the limb in a satisfactory attitude; relief from pain; return of patients to their former or useful occupations, and the discarding of appliances to aid locomotion. Motion has been a secondary consideration, stabilization of the part being considered more important. It should be remembered that these cases represent the pioneer work, and that a study of these as regards choice

of cases, improvement in technic, postoperative treatment and the class of cases amenable to this treatment, should result in better results in the cases that are to follow.

The results of the cases treated are as follows: Total number of operations, thirty-six; patients still in the hospital, six; good results at least six months after operation, eleven; good results between three and six months after operation, eight; good results less than three months after operation, five; number of patients died, four; number of patients transferred because of psychopathic condition, one; number of infections, four; sinuses after operation in tuberculous cases: (*a*) healed sinus before operation and opened after operation, one; (*b*) no sinus before operation and sinus after operation, one, and embolism following operation, four.

CONCLUSIONS

1. A study of these cases shows us a means of reclaiming patients who heretofore were condemned to a life of helpless invalidism. This is especially true of the cases of fracture and malum coxae senilis.

2. The operation should be done as early as possible when diagnosis is confirmed; and in the infectious cases when the process is healed. This overcomes the result of disuse, viz., accompanying deformities secondary to the primary one, atrophy, and the general constitutional and mental effects of being an invalid and a cripple.

3. The correction of the deformity lessens fatigue and improves the function of the limb.

The patients described were all operated on at the Hospital for the Relief of the Ruptured and Crippled. In eighteen of the cases, the operations were done by Dr. Royal Whitman; in nine, by Dr. Samuel Kleinberg, and in the remainder by seven other members of the staff.

OBSTRUCTION OF THE JEJUNUM

THE EFFECT OF SODIUM CHLORID ON THE CHEMICAL CHANGES IN THE BLOOD OF THE DOG *

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In previous articles,[1] we have called attention to certain quite constant and characteristic chemical changes taking place in the blood of the dog after experimental high intestinal obstruction. Very quickly after the obstruction is made, the chlorids of the blood begin to fall with a coincident increase in the carbon dioxid combining power of the plasma. After the store of body chlorids is depleted below a certain level, usually after a loss of about one fourth of the blood chlorids, the rise in nonprotein nitrogen previously reported by other observers [2] begins.

We have suggested that the behavior of the body chlorids is in some way related to the toxic body or bodies responsible for the characteristic toxemia. It seems very possible that the sodium chlorid, probably as hydrochloric acid, converts the toxic into nontoxic bodies. Until all the available chlorids are lost, the action of the toxic bodies is held in check. Other possible explanations for the protective action might be given. These have been enumerated and discussed elsewhere.[3]

With the vomiting which always occurs after the intestine is obstructed, there is of course some loss of chlorids. This fact has been considered by some as the sole cause of the fall in blood chlorids. We have found, however, that the characteristic changes take place in rabbits that cannot vomit,[4] have observed them in monkeys that did not vomit at any time,[5] and in patients in the entire absence of vomiting.[6] Chlorid changes similar to those seen in intestinal obstruction also have long been known to occur characteristically in lobar

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* From the University of Kansas School of Medicine.

1. Haden, R. L., and Orr, T. G.: J. Exper. Med. **37**:365 (March) 1923; ibid. **38**:55 (July) 1923; J. Missouri M. A. **20**:185 (June) 1923.

2. Tileston, Wilder; and Comfort, C. W., Jr.: Arch. Int. Med. **14**:620 (Nov.) 1914. Cooke, J. V.; Rodenbaugh, F. H., and Whipple, G. H.: J. Exper. Med. **23**:717 (June) 1916.

3. Haden (Footnote 1, second reference).

4. Haden (Footnote 1, first reference).

5. Haden, R. L., and Orr, T. G.: J. Exper. Med. **41**:107, 1925.

6. Haden, R. L., and Orr, T. G.: Bull. Johns Hopkins Hosp. **34**:26 (Jan.) 1923.

pneumonia, in which there is no objective loss of chlorids by vomiting or otherwise.[7] There is much to suggest also that in lobar pneumonia, as in intestinal obstruction, the chlorids play a protective rôle.[8]

As further proof of the direct relation of the chlorids to the toxemia of intestinal obstruction, we have reported the results of the treatment of the toxemia with sodium chlorid.[9] It has been found that a very

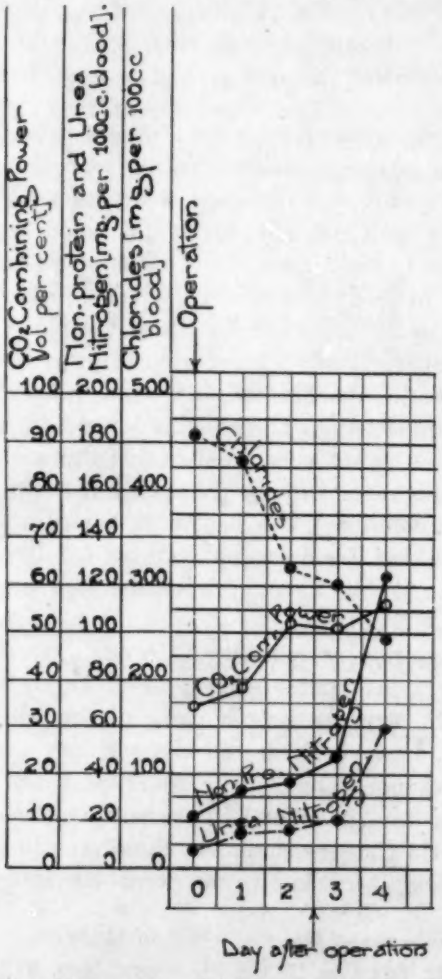

Fig. 1 (Dog 190).—Obstruction of jejunum; characteristic fall in chlorids and rise in carbon dioxid combining power and rise in nonprotein nitrogen and urea nitrogen after the chlorids have fallen below critical level. No treatment was given. The animal died on the fourth day of the experiment.

7. Peabody, F. W.: J. Exper. Med. **17**:71, 1913.

8. Haden, R. L.: Lab. & Clin. Med. **10**:337, 1925.

9. Haden and Orr (Footnote 1, second reference); J. Exper. Med. **39**:321 (Feb.) 1924.

concentrated solution of sodium chlorid may prevent the toxemia or cause a return of the blood to normal after the onset of the toxemia, even with such a serious obstruction as that of the duodenum. One dog given physiologic sodium chlorid solution daily from the beginning of an obstruction of the duodenum lived twenty-eight days without developing a toxemia. Control animals with no treatment lived from two to six days. Distilled water alone was found only to hasten death. Many other salts were tried, none of which had the protective action of sodium chlorid.[10]

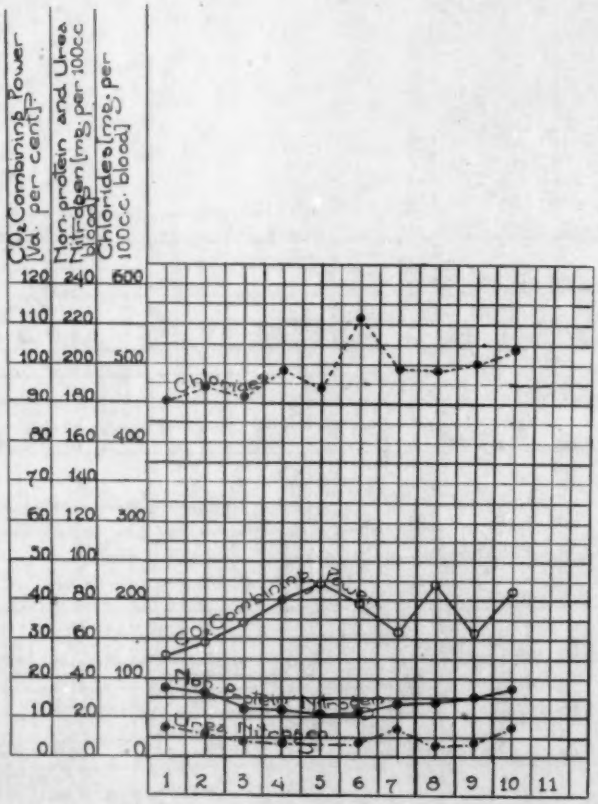

Fig. 2.—Control animal, which was bled 20 c.c. daily to determine the effect of bleeding alone. Both the chlorids and the carbon dioxid combining power show a slight rise.

The experiments reported here have been undertaken with the view of working out the most desirable method for the administration of sodium chlorid, and hence are a comparative study of the effect of this salt given in different ways. The jejunum was chosen for the site

10. Haden and Orr (Footnote 9, second reference).

of the obstruction. When the obstruction is made about 12 inches (30.4 cm.) below the duodenum, the resulting toxemia is severe and develops rapidly, but not so rapidly as to prevent any treatment. The obstruction was made at the same level in each animal. The condition dealt with here simulates closely the toxic types of obstruction of the small intestine met with clinically in man.

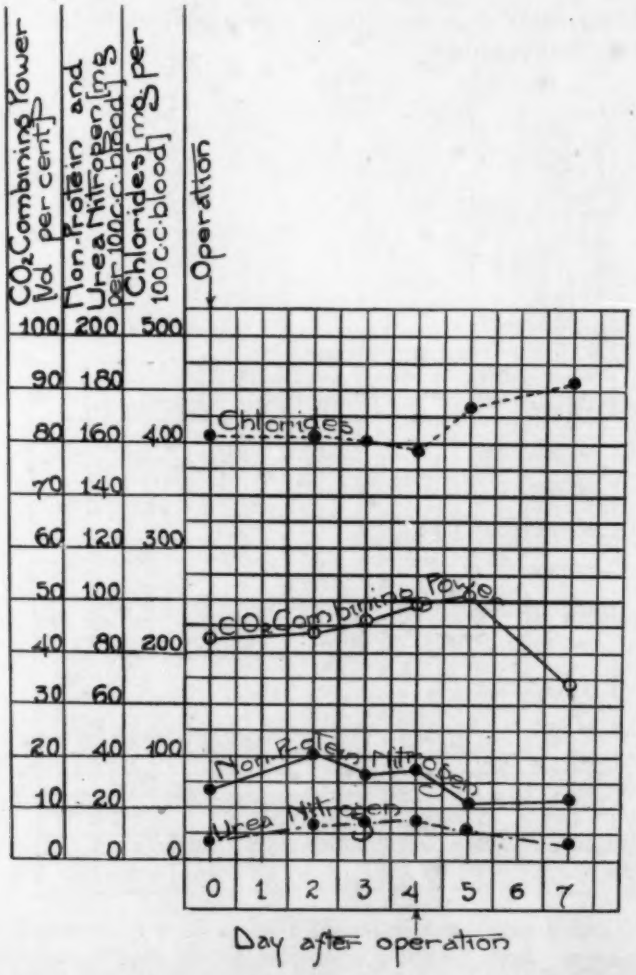

Fig. 3 (Dog 16).—Control animal in which a posterior gastro-enterostomy was done without producing any significant blood chemical changes.

METHOD

The animals were kept in metabolism cages and given no food during the course of the experiment. All operations were done under ether anesthesia with aseptic technic. Water was allowed ad libitum. Blood

for chemical analysis was obtained from the jugular vein before operation and at twenty-four hour intervals thereafter until the experiment ended with the recovery or death of the animal.

The jejunum was obstructed by section about 12 inches (30.4 cm.) below the duodenum and inversion of the cut ends. The obstruction

TABLE 1.—*Obstruction of the Jejunum in Which No Treatment Was Given*

		Blood, Amount per 100 C.c.							
Dog No.	Day After Operation	Total Nonprotein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.	Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
146	0	23.0	11.7	4.9	1.7	71	485	49.7	No treatment
	1	28.6	14.9	4.6	1.7	91	410	52.9	
	2	37.5	18.6	4.3	1.6	97	360	58.6	
	3	31.6	15.9	3.2	1.7	92	365	52.8	
									Died
159	0	30.8	8.4	3.2	1.6	71	460	43.8	No treatment
	1	32.6	14.9	2.9	1.7	93	390	41.9	
	2	58.8	27.1	3.0	1.7	90	350	40.4	
									Died
161	0	29.1	8.4	4.1	1.9	95	470	49.4	No treatment
	1	....	....	...	...	..	...	....	
	2	51.0	21.0	3.1	1.5	98	400	36.2	
									Died
163	0	....	9.8	3.4	1.4	89	415	36.2	No treatment
	1	45.0	21.9	3.5	1.5	89	380	34.3	
	2	82.5	46.7	4.0	1.5	106	320	28.7	
									Died
164	0	....	11.7	3.3	1.6	83	420	38.1	No treatment
	1	42.2	17.3	4.1	1.6	80	390	42.8	
	2	43.6	18.2	4.0	1.3	100	360	40.0	
									Died
184	0	22.8	8.4	2.6	1.7	90	460	36.2	No treatment
	1	22.9	9.3	2.9	1.7	89	421	39.0	
	2	82.5	35.5	3.0	1.4	85	300	43.4	
									Died
189	0	22.4	9.8	3.6	1.8	91	470	32.4	No treatment
	1	33.3	14.0	3.3	1.7	89	440	37.6	
	2	34.5	14.5	2.5	1.7	88	350	51.0	
	3	41.0	18.6	2.9	1.6	90	300	51.3	
	4	57.8	27.1	2.0	1.4	..	320	58.6	
	5	67.0	30.8	3.0	1.4	90	260	55.8	
	6	69.3	32.7	2.9	1.1	86	210	60.7	
	7	82.5	40.6	2.8	2.0	90	200	62.4	
	8	....	51.4	2.8	2.0	87	195	67.1	Died
190	0	21.3	8.9	3.1	1.9	83	460	34.3	No treatment
	1	32.6	13.5	2.0	1.9	90	430	37.6	
	2	36.6	15.9	1.8	1.7	87	320	52.8	
	3	47.6	20.6	2.0	1.4	89	300	51.3	
	4	123.0	59.2	2.9	1.2	..	240	56.7	
									Died
	1	....	....	...	...	..	...	....	
	2	33.62	16.8	2.9	1.6	85	390	41.4	
	3	87.3	42.0	3.0	1.9	..	260	45.7	
									Died

was thus complete in every instance. Necropsy was always performed in case of death. Peritonitis was seldom a complicating factor.

The nonprotein nitrogen and creatinin have been determined by the method of Folin and Wu;[11] the carbon dioxid combining power

11. Folin, O., and Wu, H.: J. Biol. Chem. **38**:81 (May) 1919.

by the method of Van Slyke and Cullen;[12] urea nitrogen by the Van Slyke and Cullen modification of the Marshall method;[13] uric acid by Benedict's method;[14] and the chlorids on the tungstic acid filtrate in the manner suggested by Gettler.[15]

EXPERIMENTS

Experiments have been made on forty-eight dogs. The results are tabulated in Tables 1-8. Nine dogs were given no treatment of any kind (Table 1). The duration of life was from two to six days. All show the changes in chlorids, carbon dioxid combining power, urea nitrogen, and nonprotein nitrogen characteristic of the toxemia of intestinal obstruction. The results emphasize again the absence of any significant change in the uric acid, creatinin and sugar content.

In eight dogs, a lateral anastomosis to relieve the obstruction was done after the onset of the toxemia (Table 2). The secondary operation

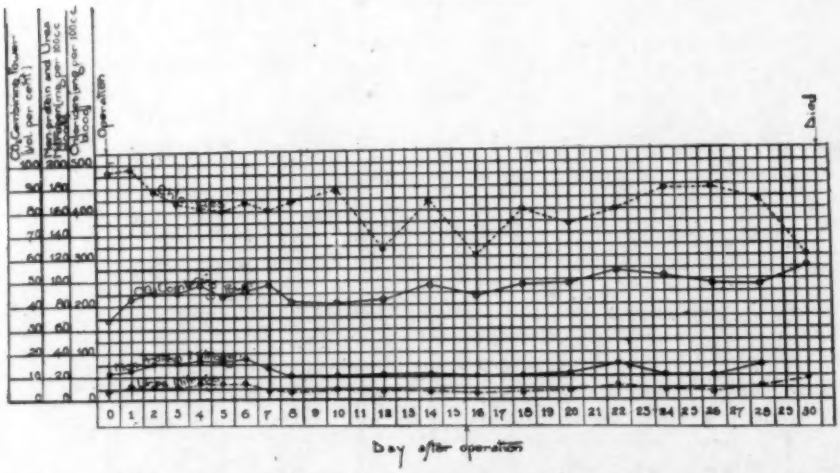

Fig. 4 (Dog 191).—Obstruction of jejunum, treated with sodium chlorid subcutaneously. This animal died of inanition thirty days after the obstruction was made. There were no clinical signs of toxemia, and the nonprotein nitrogen and urea nitrogen remained normal throughout the experiment.

was usually done on the third or fourth day after the primary operation. The animals were given no treatment except that they were allowed water ad libitum. This type of experiment simulates closely the condition and treatment usually given in cases of intestinal obstruction in man. All the animals so treated died, usually within seventy-two

12. Van Slyke, D. D., and Cullen, S. E.: J. Biol. Chem. **30**:289 (June) 1917.
13. Van Slyke, D. D., and Cullen, G. E.: J. A. M. A. **62**:1558 (May 16) 1914.
14. Benedict, S. R.: J. Biol. Chem. **51**:187 (March) 1922.
15. Gettler, A. O.: Method for Determination of Death by Drowning, J. A. M. A. **77**:1650 (Nov. 19) 1921.

TABLE 2.—*Obstruction of Jejunum and Lateral Anastomosis After Onset of Toxemia in Which No Treatment Was Given*

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Non-protein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
147	0	20.7	9.1	1.9	1.6	97	490	46.6	
	1	20.8	9.5	1.9	1.6	97	395	43.9	
	2	20.15	....	...	1.5	96	410	61.4	
	3	24.6	8.4	...	1.6	97	325	54.8	
	4	34.5	17.3	...	1.5	98	355	40.9	Lateral anastomosis
	5	98.8	40.6	...	1.5	91	320	48.5	
									Died
149	0	23.8	11.2	...	1.7	91	490	49.7	
	1	26.1	7.5	...	1.6	98	420	42.8	
	2	26.1	8.9	...	1.5	74	390	40.9	
	3	34.5	12.1	...	1.4	68	335	47.5	Lateral anastomosis
									Died
152	0	24.4	7.9	3.3	1.7	86	450	46.6	
	1	32.6	14.0	4.0	1.6	90	440	49.0	
	2	37.5	7.9	4.9	1.6	90	440	33.4	
	3	45.0	14.0	4.4	1.4	87	410	51.3	
	4	36.1	15.4	3.6	1.5	90	350	47.5	Lateral anastomosis
	5	45.6	20.1	4.0	1.3	86	340	45.7	
	6	33.7	14.0	3.5	1.4	91	350	47.5	
	7	40.0	14.0	3.2	1.4	..	315	54.1	
	8	36.1	12.2	4.4	1.4	95	355	53.2	
	9	33.7	10.3	4.0	1.3	90	350	49.9	
	10	36.1	14.9	4.0	1.2	92	360	47.5	
	11	41.0	18.6	3.2	1.2	90	360	34.3	
									Died
153	0	27.5	12.1	3.2	1.8	94	480	47.6	
	1	37.5	13.5	4.0	1.8	98	440	38.9	
	2	26.1	7.9	4.9	1.7	92	420	33.4	
	3	35.3	14.0	4.3	1.6	95	400	38.1	
	4	38.9	16.4	4.9	1.3	90	340	40.0	Lateral anastomosis
	5	36.6	15.4	4.1	1.2	95	350	39.0	
	6	36.3	11.2	3.6	1.3	98	360	40.0	
	7	30.0	9.3	5.3	1.4	..	370	53.2	
	8	33.1	10.3	5.7	1.3	91	335	55.7	
	9	27.5	8.4	4.9	1.4	87	370	47.5	
	10	30.3	14.5	5.3	1.2	90	390	39.0	
	11	45.6	20.2	4.0	1.2	86	390	38.1	
	12	73.5	33.6	3.2	1.2	80	370	30.5	
	13	74.3	33.2	3.1	1.0	78	350	30.0	
									Died
154	0	35.3	12.1	4.3	1.3	90	465	37.2	
	1	36.1	14.0	4.4	1.3	92	440	40.0	
	2	40.0	18.6	4.9	1.3	90	370	52.2	
	3	48.2	23.8	3.6	1.3	87	320	53.2	
	4	62.5	30.4	3.1	1.2	82	350	49.4	Lateral anastomosis
									Died
155	0	33.3	9.3	4.7	1.8	95	435	39.0	
	1	32.6	11.7	4.4	1.8	89	440	47.2	
	2	45.0	18.2	3.6	1.7	86	380	49.4	
	3	51.8	25.7	3.5	1.4	89	380	55.1	
	4	60.0	27.6	2.1	1.2	90	350	53.2	Lateral anastomosis
	5	77.3	42.0	2.1	1.0	89	350	47.2	
	6	86.3	42.0	2.1	1.3	82	320	48.5	
									Died
156	0	30.3	11.7	3.3	1.9	92	460	53.2	
	1	....	....	...	...	..	...	....	
	2	32.6	14.7	3.3	1.7	90	440	52.0	
	3	33.7	16.8	3.2	1.8	90	420	49.4	
	4	42.2	22.9	3.2	1.4	95	360	40.4	Lateral anastomosis
	5	57.8	24.8	4.4	1.4	105	330	45.7	
	6	60.0	29.4	4.4	1.5	108	350	50.0	In dying condition
	7	62.5	30.8	4.0	1.5	105	360	51.3	40 c.c. 2% sodium chlorid given subcutaneously
									Died
157	0	30.0	12.6	4.0	1.8	95	500	55.7	
	1	....	....	...	...	..	...	....	
	2	33.7	11.2	3.6	1.8	95	500	53.2	
	3	33.9	14.0	3.0	1.7	87	440	47.2	
	4	41.6	18.6	3.6	1.4	99	390	47.5	Lateral anastomosis
	5	52.5	28.5	4.1	1.5	102	380	48.5	
									Died

TABLE 3.—*Obstruction of Jejunum in Which Treatment with Distilled Water Was Given Subcutaneously* *

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Non-protein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
165	0	25.4	7.9	4.9	1.5	79	420	45.7	
	1	31.9	13.1	4.9	1.6	86	410	41.9	
	2	34.9	14.9	4.0	1.6	81	380	43.8	
	3	52.6	24.3	3.3	1.5	80	350	39.0	
	4	30.0	12.1	5.0	1.3	93	330	40.0	Distilled water, 9 a. m. and 4 p. m.
	5	47.6	22.4	4.9	1.3	86	340	41.9	Distilled water
									Died
167	0	30.0	8.4	5.6	1.2	98	430	38.1	
	1	31.9	8.9	5.6	1.4	91	410	41.9	
	2	34.5	10.3	4.5	1.3	103	350	41.0	
	3	38.3	10.3	4.4	1.1	95	340	41.9	
	4	....	....	...	...	..	...	....	Distilled water
	5	68.3	33.2	3.5	1.2	76	320	33.4	
									Died
172	0	28.0	8.9	4.2	1.8	90	450	46.0	Distilled water
	1	30.0	9.3	3.2	1.4	83	350	39.0	Distilled water
	2	33.3	11.2	3.4	1.3	86	330	36.2	Distilled water
									Died
177	0	37.5	7.0	2.4	1.3	79	490	45.7	Distilled water
	1	41.0	17.8	2.9	1.2	74	300	35.7	Distilled water
									Died
193	0	20.4	7.0	2.9	1.8	90	450	30.5	Distilled water
	1	24.4	10.3	2.3	1.7	89	330	31.9	Distilled water
	2	36.4	15.9	2.9	1.5	85	300	33.8	Distilled water
	3	71.3	33.2	2.9	1.2	86	270	31.5	Distilled water
									Died
194	0	21.1	7.5	2.9	1.8	95	460	31.9	Distilled water
	1	25.0	10.7	2.6	1.6	82	360	34.3	Distilled water
									Died

* The amount used was 40 c.c. per kilogram.

TABLE 4.—*Obstruction of Jejunum in Which Treatment with 1 and 2 Per Cent. Sodium Chlorid Was Given Subcutaneously* *

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Non-protein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
191	0	22.0	8.4	3.0	1.8	77	480	34.3	1% sodium chlorid
	1	26.1	11.2	2.4	1.6	86	490	43.3	1% sodium chlorid
	2	30.2	10.3	1.6	1.7	85	440	45.3	1% sodium chlorid
	3	30.3	10.3	2.0	1.5	88	420	45.7	1% sodium chlorid
	4	34.5	14.0	2.4	1.2	..	410	48.1	1% sodium chlorid
	5	33.3	14.5	2.9	1.2	80	400	43.8	1% sodium chlorid
	6	35.3	14.5	2.0	1.2	83	420	46.6	1% sodium chlorid
	7	28.0	9.3	2.0	1.4	79	460	48.1	1% sodium chlorid
	8	20.7	8.4	2.0	1.2	78	420	42.4	1% sodium chlorid
	9	....	....	...	...	..	...	....	1% sodium chlorid
	10	20.7	9.3	2.0	1.1	77	440	41.4	1% sodium chlorid
	11	....	....	...	...	..	...	....	No treatment
	12	21.4	9.8	2.0	1.1	75	320	43.8	1% sodium chlorid
	13	....	....	...	...	..	...	....	1% sodium chlorid
	14	22.4	8.4	2.0	1.1	77	420	47.5	1% sodium chlorid
	15	...	....	...	...	..	...	....	1% sodium chlorid
	16	20 .	6.5	2.2	1.0	75	300	44.7	1% sodium chlorid in a. m.
									1% sodium chlorid in p. m.
	17	....	....	...	...	..	...	....	1% sodium chlorid
	18	20.7	7.0	2.0	2.0	80	400	56.7	1% sodium chlorid
	19	....	....	...	...	..	...	....	1% sodium chlorid
	20	22.4	9.3	2.4	2.0	75	370	56.7	2% sodium chlorid
	21	....	....	...	...	..	...	....	2% sodium chlorid
	22	30.3	13.1	2.1	1.3	82	400	54.8	2% sodium chlorid
	23	....	....	...	...	..	...	....	2% sodium chlorid
	24	20.3	9.8	1.9	1.1	78	440	52.8	2% sodium chlorid
	25	....	....	...	...	..	...	....	2% sodium chlorid
	26	21.4	7.9	1.0	1.2	71	440	48.5	2% sodium chlorid
	27	....	....	...	...	..	...	....	2% sodium chlorid
	28	29.7	11.7	...	1.3	70	420	47.5	2% sodium chlorid
	29	....	....	...	...	..	...	....	2% sodium chlorid
	30	....	19.6	...	...	..	300	50.0	
	31	....	....	...	...	..	...	....	Died

* The amount used was 40 c.c. per kilogram.

hours after the operation. Two lived for a longer period. These gradually developed a toxemia and died, the chlorids of the blood continuing at a low level.

Six dogs were given distilled water, 40 c.c. per kilogram of body weight daily (Table 3). These all died in from one to five days. The

TABLE 5.—*Obstruction of Jejunum in Which Treatment with 10 Per Cent. Sodium Chlorid Was Given Intravenously*

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Non-protein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
175	0	22.4	9.8	2.9	1.8	83	440	35.3	
	1	26.8	10.3	3.9	1.6	80	370	47.5	
	2	30.0	12.6	2.3	1.3	77	370	44.7	
	3	37.5	17.8	3.9	1.1	70	360	51.9	
	4	40.0	19.6	2.5	1.4	77	270	53.8	80 c.c. 10% sodium chlorid intravenously
	5	47.6	21.5	2.3	1.2	83	360	55.1	50 c.c. 10% sodium chlorid intravenously
	6	30.0	12.1	2.9	1.1	..	390	51.0	
	7	25.7	8.9	2.9	1.1	90	400	51.3	Lateral anastomosis
	8	35.3	13.1	2.9	1.2	89	400	51.3	Died
179	0	20.7	7.0	4.2	1.7	87	440	38.1	
	1	30.0	10.7	3.1	1.5	95	400	38.1	
	2	30.0	12.1	3.3	1.4	90	350	39.0	
	3	31.8	16.4	2.5	1.5	91	290	45.7	
	4	51.8	21.0	2.0	1.2	90	260	46.0	Died during intravenous injection of 10% sodium chlorid
180	0	21.1	7.9	3.9	1.6	84	430	39.0	
	1	31.2	10.7	3.7	1.3	88	390	41.9	
	2	30.0	11.2	3.1	1.3	89	300	43.8	
	3	33.3	14.9	2.9	1.3	93	280	47.5	
	4	37.0	17.3	2.7	1.3	90	270	47.5	Lateral anastomosis 80 c.c. 10% sodium chlorid intravenously
	5	....	....	...	...	..	...	....	
	6	31.2	10.7	2.9	1.2	90	460	41.9	
	7	26.8	7.5	2.5	1.4	87	480	38.1	
	8	20.8	5.6	2.0	1.4	94	470	36.1	Dog well
181	0	22.8	7.5	3.1	1.8	88	452	38.1	
	1	22.9	9.3	2.9	1.6	85	420	37.2	
	2	28.0	11.2	3.2	1.4	87	360	40.0	
	3	31.6	14.0	4.0	1.3	90	340	41.9	
	4	55.4	26.6	4.0	1.3	89	300	43.3	Almost dead; gave 85 c.c. of 10% sodium chlorid intravenously
	5	71.3	34.6	3.9	1.2	87	352	45.7	Lateral anastomosis Died on operating table
182	0	20.8	7.0	3.9	1.3	89	470	34.3	
	1	24.8	10.3	2.9	1.6	93	430	35.3	
	2	27.7	11.7	2.6	1.4	90	370	39.0	
	3	30.3	15.4	3.5	1.4	87	355	39.0	
	4	36.6	17.8	3.2	1.2	90	310	40.9	Lateral anastomosis Given 90 c.c. 10% sodium chlorid intravenously
	5	30.0	14.9	4.0	1.2	89	375	41.9	
	6	27.7	7.5	3.9	1.2	90	380	41.9	
	7	29.4	7.0	3.7	1.1	90	380	42.8	
	8	22.2	5.6	3.2	1.2	95	420	40.0	Dog well

average duration of life after operation is less after distilled water than when no treatment is given.

One dog with obstruction of the jejunum was given a 1 or a 2 per cent. sodium chlorid solution subcutaneously daily from the beginning of the obstruction. The animal died on the thirty-first day of

starvation (Table 4). The chlorids were kept above the critical level. The urea nitrogen on the twenty-eighth day was 11.7 mg. per hundred cubic centimeters of blood and only 19.6 mg. on the thirtieth day just before death. These results verify previous findings on the protective value of physiologic sodium chlorid solution in obstruction of the duodenum.[10]

The results obtained by treatment with distilled water seems to prove definitely that the active protective agent in the saline solutions is sodium chlorid. As further proof a number of dogs were treated with concentrated solutions of sodium chlorid intravenously. Here the

TABLE 6.—*Obstruction of Jejunum in Which Treatment with 25 Per Cent. Sodium Chlorid Was Given Intravenously*

		Blood, Amount per 100 C.c.							
Dog No.	Day After Operation	Total Non-protein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.	Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
183	0	21.6	7.0	3.2	1.5	98	480	36.2	
	1	23.0	7.4	3.5	1.5	98	450	36.2	
	2	30.0	10.3	3.1	1.5	95	360	40.4	
	3	30.3	11.2	3.3	1.3	90	350	41.9	
	4	33.3	15.9	3.0	1.3	85	300	56.0	
	5	62.5	27.6	3.1	1.2	87	290	61.7	Lateral anastomosis; 50 c.c. of 25% sodium chlorid intravenously
	6	38.5	16.8	3.2	1.2	89	420	55.1	
	7	29.7	7.0	2.9	1.2	90	440	43.3	
	8	30.0	6.1	2.9	1.1	97	470	42.8	Dog well
185	0	22.7	6.1	3.2	1.8	96	440	32.8	
	1	26.1	8.4	3.6	1.8	95	400	35.7	
	2	29.4	9.8	2.9	1.7	95	390	36.6	
	3	35.3	14.9	3.0	1.4	94	330	38.5	
	4	41.6	17.8	2.9	1.4	90	295	41.4	60 c.c. of 25% sodium chlorid
	5	40.6	16.8	2.0	1.2	88	500	43.3	Died
186	0	22.8	8.4	2.6	1.7	95	450	37.6	
	1	27.0	11.2	2.9	1.8	97	410	36.6	
	2	28.9	13.1	2.6	1.6	98	360	41.4	
	3	37.5	15.1	2.9	1.5	95	310	42.4	
	4	45.0	19.2	1.7	1.2	90	290	43.3	Died during intravenous injection of 25% sodium chlorid

amount of water is so small that any good results obtained must come from the salt. Five dogs were given 10 per cent. sodium chlorid intravenously (Table 5) after the onset of the toxemia. Two animals so treated recovered following a lateral anastomosis. One died during the injection of the solution. One was almost dead when first treated. A lateral anastomosis was attempted the following day, but the animal died during the operation. One dog was first treated on the fourth day after the primary operation. The blood returned to normal, but the animal died following a lateral anastomosis. Three dogs were given a 25 per cent. solution of sodium chlorid intravenously (Table 6). One recovered with the treatment and a lateral anastomosis. One died

from shock during the treatment. The third died the day after the first treatment before a secondary operation was done.

Seven animals were treated with 2 per cent. sodium chlorid subcutaneously after the onset of the toxemia (Table 7). Five recovered. One died on the seventh day from a generalized peritonitis arising in a wound infection. One developed an abscess on the back at the site

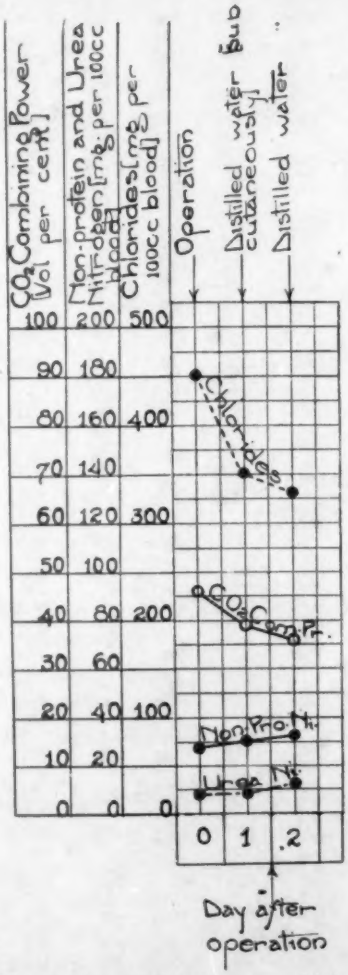

Fig. 5 (Dog 172).—Obstruction of jejunum in which the animal was given 40 c.c. per kilogram of body weight of distilled water subcutaneously each day. Death ensued even more rapidly than in control animals with no treatment, showing that water alone is not responsible for the beneficial effects of salt solution.

of the subcutaneous injections, and died three days after the obstruction was relieved. The blood nonprotein nitrogen in this animal was at the normal level. In some animals, the lateral anastomosis was done

TABLE 7.—*Obstruction of Jejunum and Anastomosis After Onset of Obstruction in Which Treatment with 2 Per Cent. Sodium Chlorid Was Given Subcutaneously*

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Nonprotein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
148	0	18.8	9.1	...	1.7	85	470	47.6	
	1	24.9	7.5	...	1.7	86	400	44.7	
	2	28.6	9.3	...	1.7	79	370	43.8	
	3	34.5	14.0	...	1.6	70	390	46.6	Lateral anastomosis 500 c.c. of 2% sodium chlorid
	4	68.3	21.0	...	1.4	68	390	48.5	500 c.c. of 2% sodium chlorid
	5	40.6	9.8	...	1.6	74	500	46.6	500 c.c. of 2% sodium chlorid
	6	35.7	9.8	...	1.5	..	570	36.2	
	7	36.1	10.7	...	1.4	68	510	40.0	500 c.c. of 2% sodium chlorid
	8	41.6	13.1	...	1.4	60	500	42.8	
	9	26.8	13.1	...	1.3	60	500	49.4	Dog well
150	0	26.1	9.8	...	1.7	90	470	50.4	
	1	30.6	11.2	...	1.7	..	430	54.1	
	2	33.3	11.2	...	1.4	79	380	40.0	
	3	39.5	12.6	...	1.2	80	370	52.2	Lateral anastomosis 360 c.c. of 2% sodium chlorid subcutaneously
	4	33.7	17 3	2.1	1.2	82	420	40.0	360 c.c. of 2% sodium chlorid subcutaneously
	5	27.3	13.1	3.9	1.2	80	490	43.8	360 c.c. of 2% sodium chlorid subcutaneously
	6	30.9	11.2	3.1	1.2	90	480	48.5	
	7	33.3	12.1	3.6	1.2	92	460	38.1	Died; generalized peritonitis from wound infection
151	0	21.6	6.5	...	1.7	98	490	48.5	
	1	34.5	11.2	...	1.7	..	380	95.7	
	2	48.2	13.1	...	1.6	80	365	45.7	
	3	46.6	15.4	...	1.3	80	350	43.8	360 c.c. of 2% sodium chlorid subcutaneously
	4	35.5	13.8	...	1.2	90	460	45.7	Lateral anastomosis 360 c.c. of 2% sodium chlorid
	5	33.7	14.0	2.2	1.2	90	450	38.1	360 c.c. of 2% sodium chlorid
	6	29.4	10.3	2.9	1.2	89	470	45.1	360 c.c. of 2% sodium chlorid
	7	30.6	10.7	3.0	1.3	90	500	41.9	
	8	27.3	7.0	3.1	1.2	94	500	37.2	
	9	32.6	7.9	3.0	1.2	92	490	36.2	Well
	10	30.0	7.0	3.4	1.1	98	520	38.1	Bleeding discontinued
160	0	30.0	10.7	3.4	1.6	89	490	45.7	
	1	31.2	14.5	3.2	1.5	90	360	44.7	
	2	41.0	18.6	3.3	1.6	98	350	45.7	
	3	....	....	...	...	..	...	....	
	4	65.0	31.3	2.8	1.7	100	340	35.7	400 c.c. of 2% sodium chlorid subcutaneously
	5	....	....	...	...	..	...	....	
	6	29.4	12.6	3.3	1.4	89	370	38.1	400 c.c. of 2% sodium chlorid subcutaneously
	7	26.1	12.6	3.4	1.6	83	400	41.9	400 c.c. of 2% sodium chlorid subcutaneously
	8	52.6	23.4	3.0	1.6	86	530	41.9	Lateral anastomosis 400 c.c. of 2% sodium chlorid subcutaneously
	9	30.0	10.7	3.5	1.7	90	550	38.1	
	10	....	....	...	...	..	...	....	
	11	26.0	8.4	3.5	1.6	118	460	45.7	
	12	24.4	6.1	3.6	1.6	105	460	44.7	Dog well
166	0	26.5	6.1	3.3	1.6	80	410	49.4	
	1	32.6	14.0	4.0	1.5	79	390	44.3	
	2	41.6	18.6	3.7	1.4	77	340	41.9	
	3	58.8	29.4	3.5	1.4	80	340	37.2	
	4	77.3	31.8	4.4	1.3	90	330	36.6	400 c.c. of 2% sodium chlorid at 9 a. m. 400 c.c. of 2% sodium chlorid at 4 p. m.
	5	65.5	30.4	4.0	1.2	88	390	45.7	400 c.c. of 2% sodium chlorid
	6	57.8	26.2	3.8	1.1	..	520	....	400 c.c. of 2% sodium chlorid
	7	38.5	18.6	4.0	1.1	70	540	43.8	Lateral anastomosis
	8	32.6	12.6	4.7	1.2	74	600	47.5	400 c.c. of 0.85% sodium chlorid
	9	36.6	12.1	5.0	1.3	70	700	32.4	Died; large abscess on back

TABLE 7.—*Obstruction of Jejunum and Anastomosis After Onset of Obstruction in Which Treatment with 2 Per Cent. Sodium Chlorid Was Given Subcutaneously.—(Continued)*

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Nonprotein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
168	0	27.5	7.9	5.7	1.5	73	420	40.0	
	1	32.6	10.3	5.8	1.3	82	370	43.8	
	2	33.0	12.1	4.6	1.4	90	370	43.8	
	3	34.5	13.1	4.1	1.2	90	350	40.9	
	4	....	....	...	...	..	...	....	
	5	51.8	23.4	4.7	1.2	90	320	39.0	600 c.c. of 2% sodium chlorid subcutaneously
	6	48.2	17.3	3.7	1.2	89	390	44.7	600 c.c. of 2% sodium chlorid subcutaneously
	7	45.6	18.6	3.3	1.2	86	500	45.7	600 c.c. of 2% sodium chlorid subcutaneously Lateral anastomosis
	8	40.6	14.0	2.9	1.1	83	610	43.8	
	9	33.3	13.1	3.0	1.2	75	560	40.0	
	10	27.0	8.4	2.9	1.2	76	520	36.2	
	11	....	6.5	3.1	1.2	71	540	36.2	Dog well
170	0	30.3	9.3	3.6	1.4	86	400	32.4	
	1	30.3	9.8	3.0	1.5	85	390	32.4	
	2	....	....	...	...	..	...	....	360 c.c. of 2% sodium chlorid subcutaneously
	3	30.3	13.5	2.3	1.6	90	400	38.1	
	4	35.7	14.0	2.1	1.5	91	390	41.9	
	5	36.1	14.9	2.1	1.3	83	380	41.9	360 c.c. of 2% sodium chlorid subcutaneously
	6	35.3	16.4	2.5	1.1	87	400	42.8	360 c.c. of 2% sodium chlorid subcutaneously
	7	40.0	17.3	2.1	1.1	86	440	38.1	Lateral anastomosis
	8	37.5	11.7	1.9	1.2	80	440	34.3	
	9	....	....	...	...	..	...	....	
	10	25.0	7.0	1.6	1.1	78	460	41.9	Well; bleeding discontinued

and the first treatment given at the same time. The best results were obtained, however, in animals that had been treated for at least twenty-four hours before operation. Several animals were treated for forty-eight hours, and several for seventy-two hours before the obstruction was released. By such treatment, the nonprotein nitrogen was always lowered.

The results previously reported have convinced us of the value of sodium chlorid as a protective agent. They indicate that the solution should be given subcutaneously and intravenously. When the concentrated sodium chlorid solutions were given, however, several animals died as a result of the injection, seemingly from heart failure. To obviate, if possible, any ill effects of the sodium chlorid alone, a salt mixture was devised containing calcium and potassium chlorids also, in the same proportion as Ringer's solution. Since there is quite uniformly an alkalosis in high intestinal obstruction, a small amount of ammonium chlorid also has been added. This salt produces an acidosis, as pointed out by Haldane.[16] The mixture, as finally employed,

16. Haldane, J. B. S.: J. Physiol. **55**:265 (Aug.) 1921.

TABLE 8.—*Obstruction of Jejunum in Which Treatment with Salt Mixture Was Given Subcutaneously and Intravenously*

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Non-protein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
199	0	20.7	7.5	3.0	1.9	96	490	33.8	
	1	27.0	13.1	1.8	1.5	90	440	37.2	
	2	53.6	25.2	2.0	1.2	95	350	45.3	
	3	60.0	30.0	2.0	1.3	97	290	47.1	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	4	32.6	15.9	2.2	1.2	93	460	48.1	40 c.c. per kg. 1% salt mixture subcutaneously; obstruction released
	5	31.2	14.5	1.5	1.4	87	510	47.5	40 c.c. per kg. 1% salt mixture subcutaneously
	6	34.5	14.5	1.8	1.4	85	500	41.9	
	7	30.9	11.7	1.5	1.1	80	500	38.1	
	8	23.8	9.8	2.0	1.1	81	490	38.1	
									Animal well
200	0	21.1	7.9	2.9	1.8	95	470	35.7	
	1	27.3	7.9	2.8	1.6	90	400	31.5	
	2	32.6	14.5	3.0	1.3	95	410	44.3	
	3	42.2	24.3	2.9	1.3	95	290	44.3	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	4	29.7	14.0	2.9	1.2	90	430	48.1	40 c.c. per kg. 1% salt mixture subcutaneously; obstruction released
	5	23.0	12.6	2.0	1.3	79	470	47.5	
	6	54.6	28.0	3.0	1.3	80	470	42.8	40 c.c. per kg. 1% salt mixture subcutaneously
	7	30.3	9.3	2.9	1.1	81	500	37.6	
	8	24.6	7.5	2.0	1.0	82	460	36.2	
									Animal well
201	0	20.7	9.8	2.9	1.8	90	460	26.2	
	1	20.7	8.9	3.0	1.8	90	460	30.0	
	2	22.2	10.3	3.1	1.6	97	400	31.9	
	3	30.0	14.9	1.8	1.5	82	350	43.3	
	4	45.6	18.6	1.7	1.5	82	290	47.5	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	5	32.6	8.9	2.9	1.2	83	400	47.5	40 c.c. per kg. 1% salt mixture subcutaneously; obstruction released
	6	22.2	6.5	2.0	1.1	85	410	40.9	
	7	20.5	7.0	1.6	1.2	93	440	40.0	
									Animal well
202	0	20.2	7.9	2.6	1.8	90	480	28.1	
	1	22.2	10.3	2.4	1.8	90	470	29.0	
	2	24.6	10.7	2.9	1.5	95	380	30.9	
	3	30.3	13.1	2.0	1.4	89	330	36.2	
	4	54.6	25.7	2.0	1.2	83	285	41.9	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	5	34.9	14.0	2.0	1.2	85	410	39.0	40 c.c. per kg. 1% salt mixture subcutaneously; obstruction released
	6	23.4	7.8	1.9	1.1	86	460	31.5	
	7	22.8	7.9	1.4	1.1	87	470	31.5	
									Animal well
203	0	21.1	9.8	2.1	1.7	93	475	32.4	
	1	34.1	14.0	2.0	1.7	89	410	32.4	
	2	125.0	58.4	2.9	1.4	89	360	40.0	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	3	82.5	35.5	8.0	1.5	80	400	51.3	40 c.c. per kg. 1% salt mixture subcutaneously
									Died; obstruction not released
204	0	20.4	9.3	2.0	1.7	91	460	30.5	
	1	23.0	11.2	2.2	1.6	90	400	31.5	
	2	40.0	19.6	2.0	1.5	93	350	36.2	
	3	51.8	24.3	2.0	1.3	87	310	38.1	
	4	60.0	27.1	2.2	1.2	90	290	41.9	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	5	37.5	9.3	1.7	1.2	84	410	51.3	Obstruction released
	6	22.2	10.3	1.9	1.4	87	400	43.8	
	7	131.5	61.6	1.4	1.2	87	440	58.9	
	8	289.0	133.1	2.0	2.3	86	250	68.3	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously

TABLE 8.—*Obstruction of Jejunum in Which Treatment with Salt Mixture Was Given Subcutaneously and Intravenously.—(Continued)*

Dog No.	Day After Operation	Blood, Amount per 100 C.c.						Carbon Dioxid Combining Power, per Cent. by Volume	Remarks
		Total Non-protein Nitrogen, Mg.	Urea Nitrogen, Mg.	Uric Acid, Mg.	Creatinin, Mg.	Sugar, Mg.	Chlorids, Mg.		
	9	198.0	33.6	2.0	2.1	85	390	62.4	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
									Died; generalized peritonitis; entero-enterostomy obstructed
205	0	20.7	8.4	2.6	1.6	87	440	26.8	
	1	31.2	13.1	2.0	1.6	88	415	30.5	
	2	32.3	12.6	1.9	1.6	80	380	30.5	
	3	32.3	14.9	2.0	1.4	86	350	34.3	
	4	33.3	15.4	1.9	1.4	90	320	47.5	
	5	51.8	24.8	2.0	1.3	91	250	49.4	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	6	28.5	6.5	1.6	1.2	90	390	51.4	40 c.c. per kg. 1% salt mixture subcutaneously
	7	29.7	8.4	1.9	1.2	89	400	43.8	40 c.c. per kg. 1% salt mixture subcutaneously
	8	32.3	14.0	1.9	1.9	86	440	46.2	40 c.c. per kg. 1% salt mixture subcutaneously; lateral anastomosis
	9	31.2	9.3	1.6	1.4	..	430	41.9	
	10	20.2	6.1	1.6	1.1	93	480	36.2	
	11	20.7	5.1	1.6	1.0	85	470	35.7	
									Animal well
206	0	20.3	6.1	2.9	1.8	90	440	28.7	
	1	23.8	9.3	2.9	1.6	86	410	32.4	
	2	30.0	13.5	2.9	1.5	82	370	31.5	
	3	33.3	15.4	2.4	1.5	85	335	35.3	
	4	35.3	15.9	2.0	1.4	86	330	47.5	
	5	54.6	24.3	1.9	1.2	89	230	40.9	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	6	30.9	8.4	2.0	1.1	86	400	45.7	40 c.c. per kg. 1% salt mixture subcutaneously
	7	27.3	7.0	1.9	1.2	85	390	34.4	40 c.c. per kg. 1% salt mixture subcutaneously
	8	30.6	10.7	1.9	1.2	85	400	50.7	40 c.c. per kg. 1% salt mixture subcutaneously; lateral anastomosis
	9	32.6	9.8	1.6	1.0	..	430	45.3	
	10	20.8	8.4	1.4	1.1	80	480	42.8	
	11	21.1	5.6	1.2	1.2	80	450	35.7	
									Animal well
207	0	26.1	9.3	3.0	1.7	87	460	32.4	
	1	58.8	32.7	2.9	1.6	87	400	35.7	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	2	48.2	19.2	2.6	1.6	..	480	37.6	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
	3	36.6	21.5	2.2	1.4	80	410	38.5	40 c.c. per kg. 1% salt mixture subcutaneously
	4	30.0	14.0	2.2	1.1	80	460	38.5	40 c.c. per kg. 1% salt mixture subcutaneously
	5	45.6	20.6	2.0	1.0	83	410	40.4	40 c.c. per kg. 1% salt mixture subcutaneously; lateral anastomosis
	6	33.3	14.0	2.0	1.1	80	440	39.5	40 c.c. per kg. 1% salt mixture subcutaneously
	7	31,6	12.6	1.9	1.0	89	500	38.1	
									Animal well
208	0	21.8	8.4	2.9	1.7	90	450	30.5	
	1	33.3	14.0	2.9	1.7	89	410	31.9	
	2	33.3	11.2	2.0	1.5	..	340	35.7	
	3	29.4	11.7	1.9	1.4	90	300	34.7	
	4	33.3	16.8	2.0	1.2	87	280	36.6	
	5	52.6	23.8	2.0	1.4	85	280	39.5	40 c.c. per kg. 1% salt mixture subcutaneously; 5 c.c. 5% solution intravenously
									Lateral anastomosis
	6	41.6	6.5	1.9	1.2	85	390	39.5	
	7	25.0	7.0	1.9	1.0	87	420	38.1	
	8	30.3	11.2	1.9	1.0	85	360	31.9	
									Animal well

has the following composition: sodium chlorid, 9 parts; ammonium chlorid, 0.5 parts; calcium chlorid, 0.3 parts, and potassium chlorid, 0.2 parts.

Ten dogs were treated with the salt mixture (Table 8). A 1 per cent. solution was employed subcutaneously and a 5 per cent. solution intravenously. Each dog was given both subcutaneous and intravenous

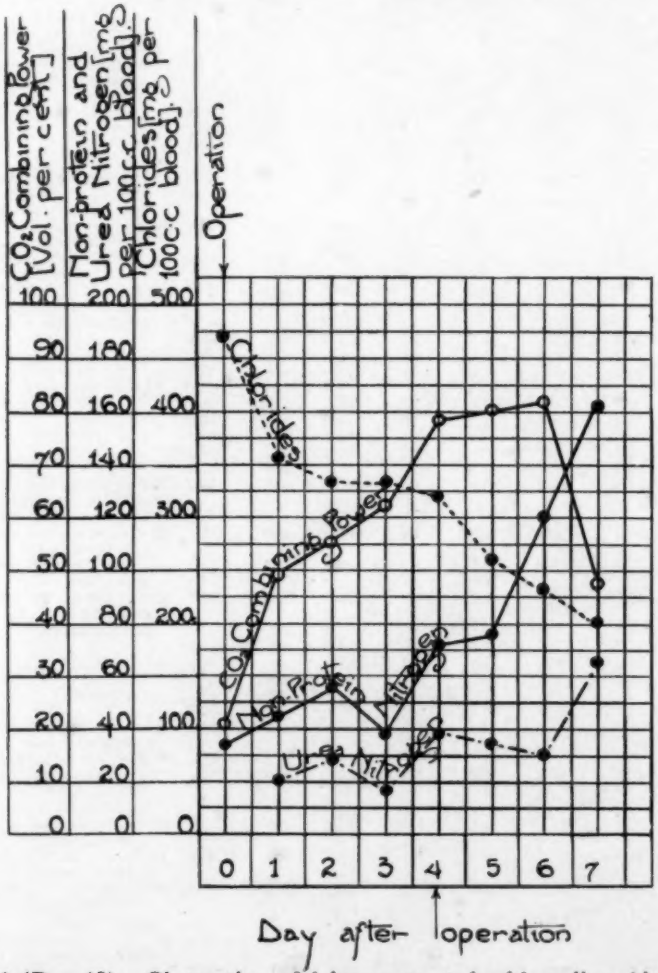

Fig. 6 (Dog 18).—Obstruction of jejunum treated with sodium bicarbonate solution subcutaneously; marked alkalosis as indicated by rise in carbon dioxid combining power to four times the initial value. The treatment did not affect the toxemia as shown by the course of the chlorids, nonprotein nitrogen and urea nitrogen. The animal died on the seventh day of the experiment.

treatment. The treatment was not begun until the toxemia, as evidenced by a rise in the nonprotein nitrogen, had begun. Eight of the ten animals so treated recovered. The findings in the blood are shown in

Table 8. One animal developed peritonitis and died. One had a toxemia of very rapid course. The treatment lowered the level of the nonprotein nitrogen in the blood. The animal died, however, before the release operation was done. The decrease in nonprotein nitrogen in the blood was most striking in every case. All animals were treated for at least twenty-four hours before the lateral anastomosis was done. In several

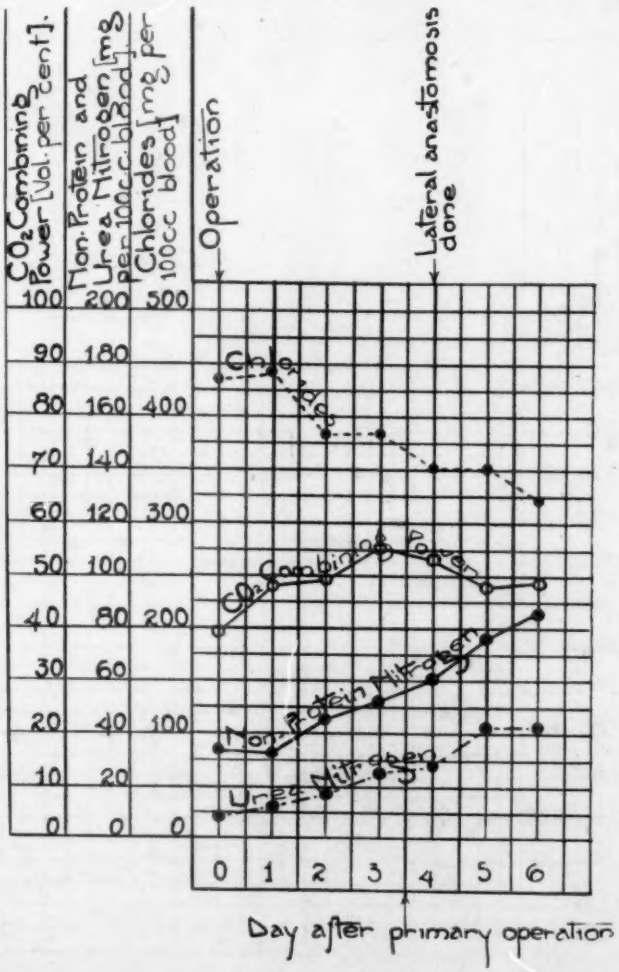

Fig. 7 (Dog 155).—Obstruction of jejunum in which a lateral anastomosis was done after the onset of the toxemia. The chlorids continued to fall and the nonprotein nitrogen and urea nitrogen to rise unaffected by the release of the obstruction. No other treatment was given.

animals, the secondary operation was not done for three days after the treatment had been begun and the toxemia checked. In one dog, the interval was four days.

COMMENT

The results reported here are largely confirmatory of previous experiments. In this series, the operations were all done in the same manner and at the same level in the intestine. The only differences were the normal individual variations in animals and the varying methods of treatment. The untreated animals all developed the characteristic changes in the blood. The animals given only distilled water died more quickly than those given no treatment. In the animals subjected to a

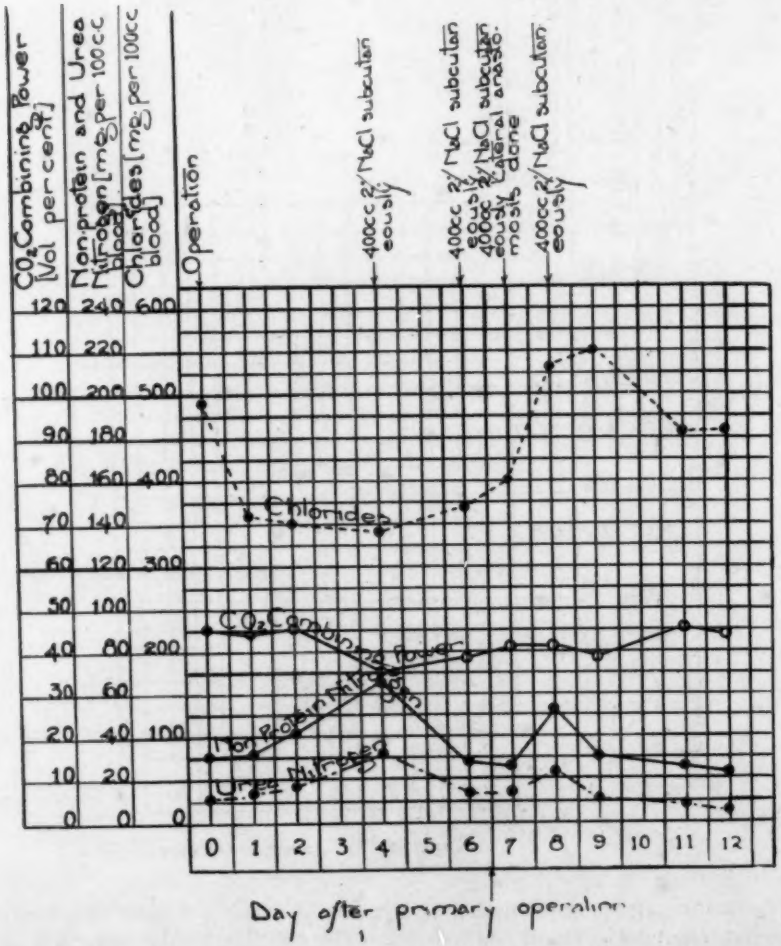
CO2 Combining Power [Vol per cent.]
Nonprotein and Urea Nitrogen [mg. per 100 cc blood]
Chlorides [mg. per 100 cc blood]
Operation
400 cc 2% NaCl subcutaneously
400 cc 2% NaCl subcutaneously
400 cc 2% NaCl subcutaneously
Lateral anastomosis done
400 cc 2% NaCl subcutaneously
Chlorides
CO2 Combining Power
Nonprotein Nitrogen
Urea Nitrogen
Day after primary operation

Fig. 8 (Dog 160).—Obstruction of jejunum with characteristic fall in chlorids followed by rise in nonprotein nitrogen and urea nitrogen. Treatment was given subcutaneously with 2 per cent. sodium chlorid after the onset of the toxemia, which was followed by a rapid return of the blood chemistry to normal. Later anastomosis was done on the seventh day. The dog recovered.

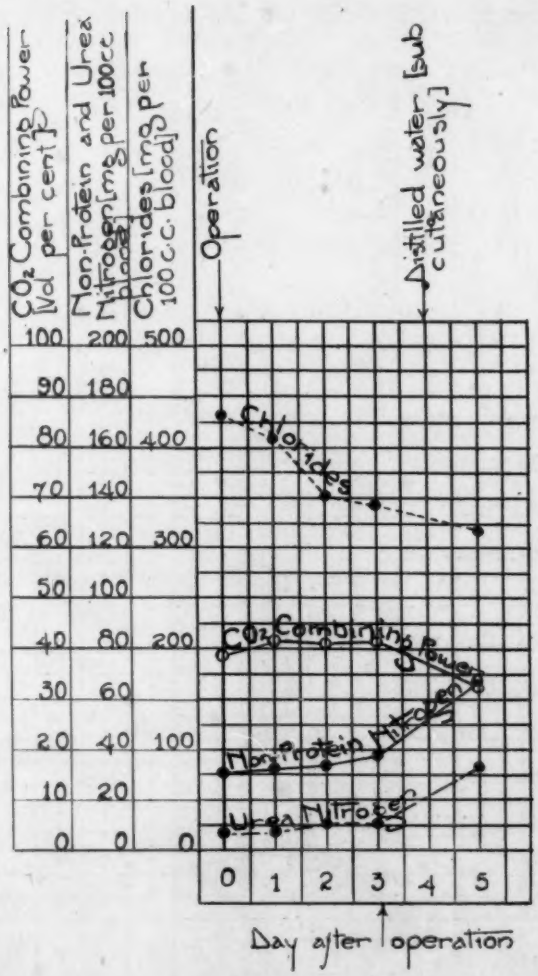

Fig. 9 (Dog 167).—Obstruction of jejunum in which the animal was given distilled water subcutaneously after the onset of toxemia without affecting the course. Death ensued twenty-four hours after treatment was begun.

secondary operation, the condition encountered in patients clinically was closely simulated.

In one series, the obstruction was relieved by a lateral anastomosis at the onset of the toxemia. Eight dogs so treated died. The operation relieved the mechanical condition but had no effect on the toxemia.

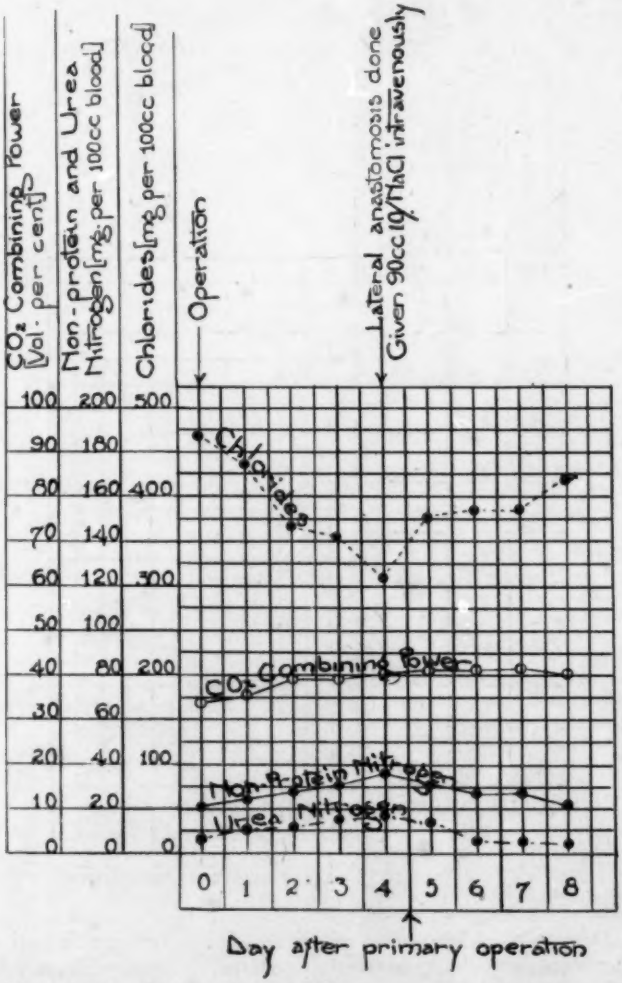
CO_2 Combining Power (Vol. per cent)
Non-protein and Urea Nitrogen (mg. per 100cc blood)
Chlorides (mg. per 100cc blood)
Operation
Lateral anastomosis done
Given 90cc 10% NaCl intravenously
100 90 80 70 60 50 40 30 20 10 0
200 180 160 140 120 100 80 60 40 20 0
500 400 300 200 100 0
CO_2 Combining Power
Non-Protein Nitrogen
Urea Nitrogen
0 1 2 3 4 5 6 7 8
Day after primary operation

Fig. 10 (Dog 114).—Obstruction of jejunum treated with 10 per cent. sodium chlorid solution given intravenously. The dog recovered after lateral anastomosis.

The use of sodium chlorid solution to combat the toxemia gave very excellent results. Operation alone usually had no influence on the level of nonprotein nitrogen and chlorids. By supplying sufficient chlorid to bring the blood chlorids to the normal level, a rapid fall in

nonprotein nitrogen to the normal followed. That the sodium chlorid is the essential and active factor is proved by the fact that distilled water alone only hastens death, and that the toxemia may be alleviated by the use of very concentrated salt solutions intravenously. In the latter instance, the fluid is so small as to be a negligible factor.

The one dog given sodium chlorid daily from the onset of the obstruction is a striking example of the power of sodium chlorid to prevent entirely the formation of toxic bodies or to protect the body

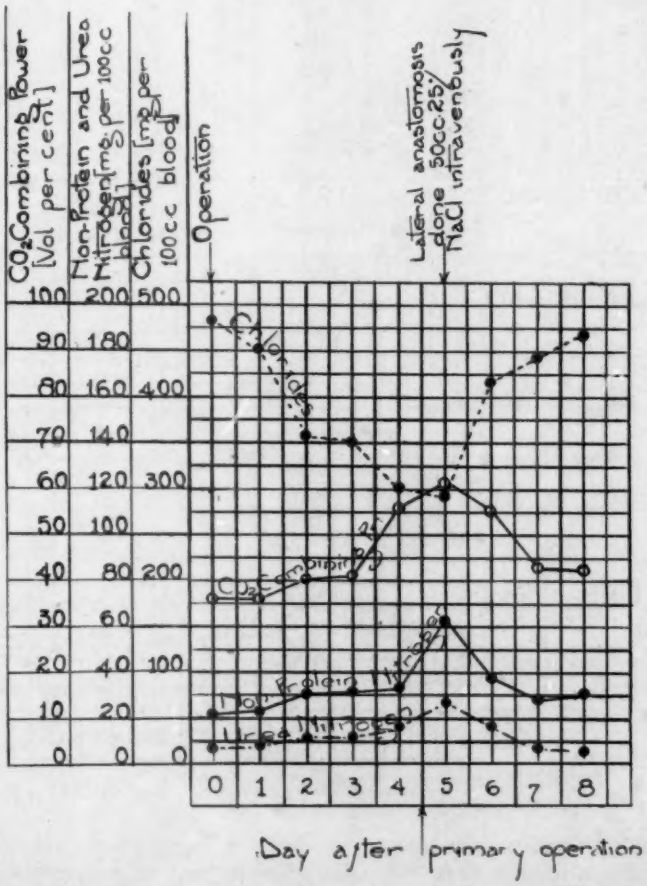
CO2 Combining Power [Vol per cent.]
Non-Protein and Urea Nitrogen [mg. per 100 cc blood]
Chlorides [mg. per 100 cc blood]
Operation
Lateral anastomosis done 50 cc 25% NaCl intravenously
100 90 80 70 60 50 40 30 20 10 0
200 180 160 140 120 100 80 60 40 20 0
500 400 300 200 100 0
0 1 2 3 4 5 6 7 8
Day after primary operation

Fig. 11 (Dog 106).—Obstruction of jejunum treated intravenously with 50 c.c. of 25 per cent. sodium chlorid solution after the onset of toxemia. The animal recovered after a lateral anastomosis.

against the toxic substances. This animal lived thirty days, finally dying of exhaustion without ever developing a toxemia.

The results in this series of animals treated with the salt mixture were excellent. One died from a generalized peritonitis arising in a wound infection. Another died before the obstruction could be released,

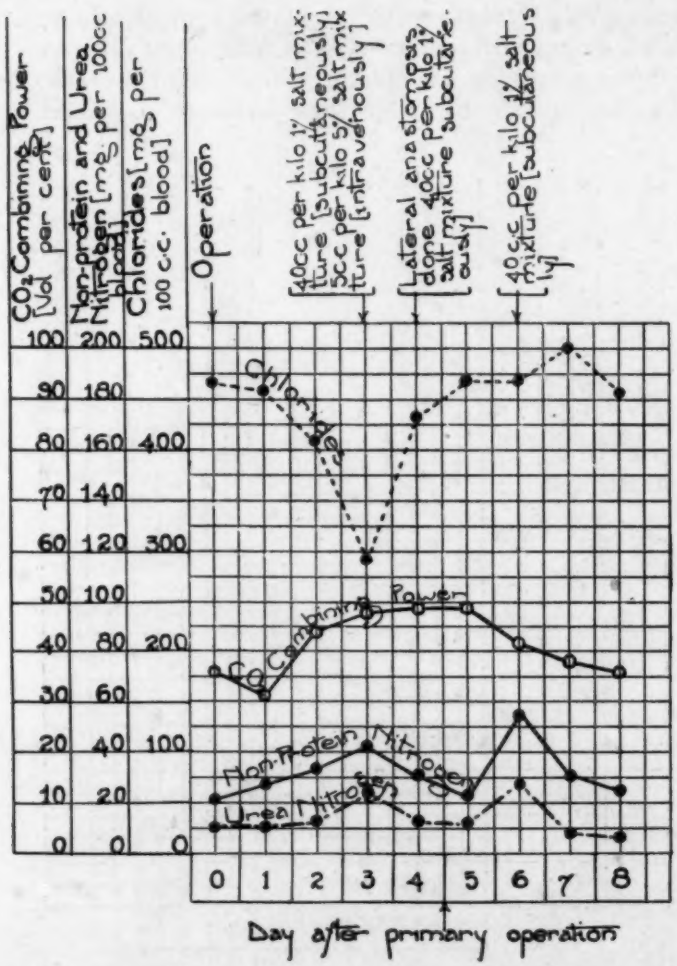
CO2 Combining Power [Vol per cent]
Non-protein and Urea Nitrogen [mg. per 100cc blood]
Chlorides [mg. per 100 c.c. blood]
Operation
40cc per kilo ½ salt mixture [subcutaneously] 5cc per kilo 5% salt mixture [intravenously]
Lateral anastomosis done 40cc per kilo ½ salt mixture subcutaneously
40 c.c. per kilo ½ salt mixture [subcutaneously]
Chlorides
CO2 Combining Power
Non-Protein Nitrogen
Urea Nitrogen
Day after primary operation

Fig. 12 (Dog 200).—Obstruction of jejunum, with characteristic fall in chlorids, rise in carbon dioxid combining power and in nonprotein nitrogen and urea nitrogen. The animal was treated subcutaneously and intravenously with salt mixture. Twenty-four hours after treatment, the chlorids had risen and the nonprotein nitrogen and urea nitrogen had fallen. Lateral anastomosis was done at this point with complete recovery of the animal.

although the salt mixture was of value in markedly reducing the toxemia. The other eight animals were given no treatment until the toxemia was well advanced and, usually, serious enough to cause death within twenty-four hours. By treatment the toxemia could be neutralized. For example, Dog 205 on the fifth day of obstruction, had a nonprotein nitrogen of 51.8 mg. per hundred cubic centimeters. The following day, after intravenous and subcutaneous treatment with the salt mix-

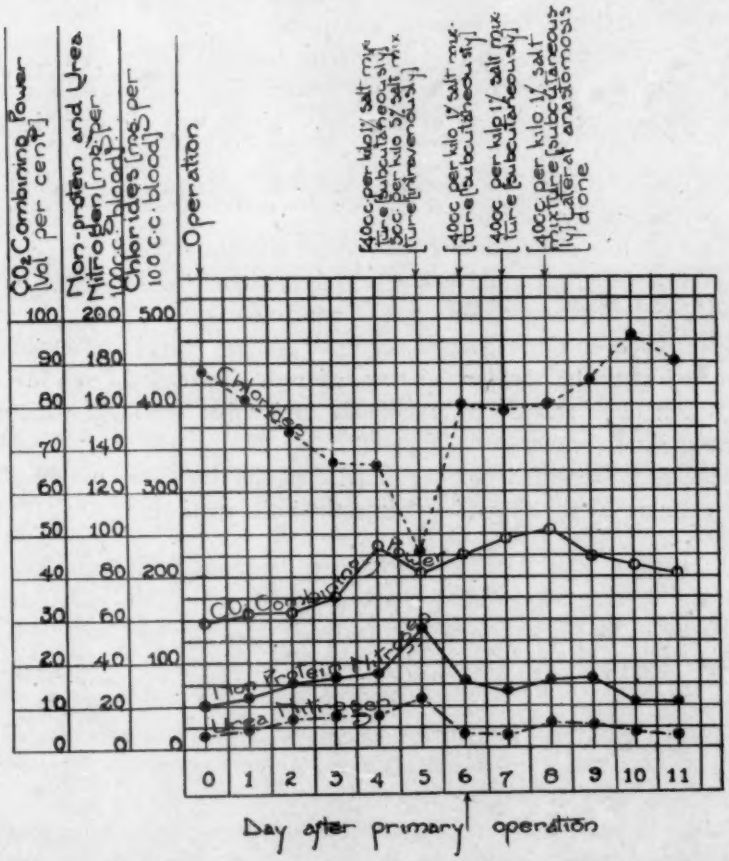
CO2 Combining Power (Vol per cent)
Non-protein and Urea Nitrogen (mg. per 100 c.c. blood)
Chlorides (mg. per 100 c.c. blood)
Operation
40 cc. per kilo 1% salt mixture (subcutaneously) 50 cc. per kilo 5% salt mixture (intravenously)
40 cc. per kilo 1% salt mixture (subcutaneously)
40 cc. per kilo 1% salt mixture (subcutaneously)
40 cc. per kilo 1% salt mixture (subcutaneously) Lateral anastomosis done
Chlorides
CO2 Combining Power
Non-protein Nitrogen
Urea Nitrogen
Day after primary operation

Fig. 13 (Dog 121).—Obstruction of jejunum treated with salt mixture subcutaneously and intravenously after the onset of toxemia. The blood chemistry findings returned to normal and remained so. A lateral anastomosis was done four days after the treatment was begun, on the eighth day after the obstruction was made. The animal recovered.

ture, the nonprotein nitrogen had dropped to 28.5 mg. and the urea nitrogen to 6.5 mg. The blood nitrogen was kept at approximately the same level by daily treatments, the lateral anastomosis being done on the eighth day.

SUMMARY AND CONCLUSIONS

In experiments on forty-eight dogs with obstruction of the jejunum, to determine the most desirable method of administration of chlorids as a protective measure against the toxemia of intestinal obstruction, nine dogs were given no treatment of any kind. All died in from two to eight days after the primary operation.

A lateral anastomosis to relieve the obstruction was done in eight animals after the onset of the toxemia, and all died in from one to nine days after the anastomosis was done.

One animal was given 1 or 2 per cent. sodium chlorid subcutaneously daily from the onset of the obstruction. This animal lived thirty days, finally succumbing to exhaustion. There was no toxemia at any time.

Six dogs were given distilled water subcutaneously, and all died in from two to five days.

Two of five dogs given 10 per cent. sodium chlorid intravenously, and one of three given 25 per cent. intravenously were relieved of the toxemia and recovered after a lateral anastomosis.

Five of seven dogs given 2 per cent. sodium chlorid subcutaneously recovered after the obstruction was relieved. Two died from infection.

Of ten dogs treated intravenously and subcutaneously with a salt mixture, eight recovered.

The data presented here emphasize again the value of chlorids in the treatment of the toxemia of intestinal obstruction.

PAINFUL CONDITIONS IN THE LUMBAR LUMBO-SACRAL AND SACRO-ILIAC REGIONS

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The character of low back pain varies from a dull, heavy sensation which simply annoys and depresses, to a sharp, agonizing spasm which is unendurable without sedatives. The cause of the pain is equally variable. The underlying pathologic condition may be located in tissues distant from the seat of the pain; on the other hand, the bony spine itself may be undergoing destruction by disease. Staub lists about sixty causes of low back pain, and even then the possibilities are not exhausted.

Confronted with such a multiplicity of symptoms and causes, diagnosis usually is difficult or uncertain, and consequently treatment is unsatisfactory. In attempting to make a diagnosis, it is absolutely necessary to have some sort of plan as a working basis; and the rough classification given in the accompanying table has been found to be of value.

Gynecologic Conditions.—Formerly, almost all low back pain in women was thought to be gynecologic in nature, and was ascribed to such conditions as malposition of the uterus, prolapse of the ovary and cervical tears. This was due, in part, to the fact that the pain was apt to be aggravated by the menstrual period. It is now generally believed that only a small percentage of low back pain is due to gynecologic conditions. Neoplasms and inflammatory conditions of the pelvic organs may, however, involve nerve roots, so that in all cases of low back pain in women it is wise to have the patients examined gynecologically and treated accordingly.

Genito-Urinary Conditions.—As a rule, genito-urinary troubles do not cause low back pain, but prostatic inflammation is said to cause a pain in the region of the sacrum; and reflex pain and spasm from urinary calculi have even been mistaken for tuberculosis of the spine. Aching pains in the lumbar region may be associated with hydronephrosis. A careful history and a rectal, urinary and roentgen-ray examination should be sufficient to enable one to diagnose the genito-urinary condition, and appropriate treatment should follow.

Medical Conditions.—Many medical conditions are associated with low back pain, but three of these merit special attention, viz., constipation, nervous backache and spinal inefficiency.

Constipation, acting either by the pull of the distended bowel or through the absorption of toxins, seems to be the cause of some backache, and the pain disappears when the constipation is relieved.

Some backaches seem to be purely neurotic in character. One author, writing facetiously on the subject, narrates the case of a man who always suffered from a violent backache whenever he went shopping with his wife.

Classification of Low Back Pain for Purposes of Diagnosis

- Long Standing Cases
  - Gynecologic
  - Genito-urinary
  - Medical
    - Constipation
    - Nervous, neurotic or hysterical
    - Spinal inefficiency
  - Static
    - Weak feet
    - Bad posture
    - Scoliosis
    - Chronic strain
      - Large abdomen
      - Occupational strain (surgeons and dentists)
  - Conditions shown by roentgen-ray examination
    - Osteoarthritis
    - Abnormalities of bone
- Acute or Subacute Cases Without Trauma
  - Associated with fevers
  - Myalgia
  - Toxemias
  - Diseases
    - Osteomyelitis
    - Infectious arthritis
    - Gonorrhea
    - Typhoid fever
    - Tuberculosis
    - Syphilis
    - Neoplasms
  - Cord tumors
- Trauma Cases
  - Roentgen-ray examination positive
    - Fracture
    - Dislocation
    - Kümmel's disease
  - Roentgen-ray examination negative—strain or sprain
    - Lumbar
    - Lumbosacral
    - Sacro-iliac

Certain cases of backache are due to what, for want of a better term, may be called spinal inefficiency. In these persons, the spinal column seems not to be strong enough to support them in their daily work. In such cases, a light spinal support usually will give relief.

Static Conditions.—Weak feet are not an uncommon cause of backache, and when this condition is corrected the backache disappears.

Bad posture, tending either to an exaggeration of the lumbar lordosis or to an obliteration of this curve, may be the cause of pain, and improved posture clears up the trouble.

Scoliosis may be the cause of backache, but not as frequently as might be expected.

CHRONIC STRAINS

The bony framework of the body is held together at its various articulations by ligaments, and through the agency of muscles, motion and change of position are possible. There are certain positions that make for strength and stability, other positions that predispose to strain. The former require but little muscular effort to maintain them, while the latter rapidly use up muscular strength.

As the muscles tire in maintaining a weak position, more and more tension falls on the ligaments. These structures, while poor in blood supply, are fairly well furnished with nerves; consequently, when subjected to unusual tension, a painful strain results.

One of the common causes of chronic strain of the lower back is a large abdomen, which, by its weight and downward and forward pull, tires the muscles and thus puts an increased tension on the ligaments supporting the lumbar spine. The obvious treatment of such a condition would be to reduce the size of the abdomen by dieting, or, failing in this, to try to relieve the strain on the lumbar spine by supporting the abdomen. In supplying a support to the abdomen, it should be borne in mind that it will not lessen the strain to use a belt no wider in the back than the lumbar spine itself; to be of any real benefit, the support must be anchored at the back well above and well below the lumbar spine.

Probably the most common cause of chronic strain of the lower back is occupational or attitudinal. The individual stands and works for long intervals with the body bent forward at the waist. In such cases, the muscles eventually tire and the back ligaments get the strain. This condition is common among surgeons and dentists, and may sometimes be relieved by the simple expedient of working with one foot elevated on a small block or platform.

Conditions Shown by Roentgen-Ray Examination.—Every patient with pain in the back should be subjected to a thorough roentgen-ray examination, which sometimes will disclose the cause of the trouble. A common condition found in middle-aged and elderly people is osteoarthritis of the spine. The roentgenograms may show bony deposits by the side of the spine, lipping of the edges of the vertebral bodies, or spur formation. The pain in ostearthritis would seem to be due to chance nerve root pressure, since, at times, considerable pain may be present with comparatively few ostearthritic changes, while in other

cases there may be marked ostearthritis, even to long, interlocking spur formation, and little associated pain. Local irritation of a chronic type (strain) may lead to ostearthritic changes in the spine and in the sacro-iliac joints.

Daub [1] has recently described cases in which, in his opinion, the low back pain complained of has been due to a calcification of the iliolumbar ligaments.

Sorrel and Delahaye [2] diagnose, by roentgen-ray examination, a condition that they call "painful epiphysitis of adolesence." Roentgenograms show the epiphyseal centers formed in advance of the age of the patient. Calvé [3] describes a case of localized affection of the spine suggesting ostechondritis of the vertebral body.

Blaine [4] reports cases of pain in the sacro-iliac region in which roentgen-ray examination shows an "arthrosis obliterans" of the sacro-iliac joints.

ABNORMALITIES OF BONE

The lumbar, lumbosacral and sacro-iliac regions seem prone to irregularities of structure, and many abnormalities have been found and described.

For example, Goldthwait [5] discusses a condition in which the twelfth rib may become caught on the lateral process of the first lumbar vertebra. Marshall [6] reports a case in which there was a long process on the right side of the first lumbar vertebra (a supernumerary rib). Painful symptoms were due, in his opinion, to squeezing of the soft tissues, including the twelfth dorsal nerve, between this supernumerary rib and the twelfth rib.

Brackett [7] enumerates the abnormalities that may be present as follows: Impinging spinous processes; impinging transverse processes (on the ilium); sacralization of the fifth lumbar vertebra (particularly unilateral); abnormal articular facets between the fifth lumbar vertebra

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1. Daub: The Rôle of Ligamentous Calcification in Lower Back Pain, Am. J. Roentgengol., August, 1924.

2. Sorrel, E., and Delahaye, A.: Growth Epiphysitis, Presse méd. **32**:727 (Sept.) 1924.

3. Calvé: A Local Affection of the Spine Suggesting Osteochondritis of the Vertebral Body, J. Bone & Joint Surg., January, 1925.

4. Blaine, E. S.: Sacro-Iliac Arthrosis Obliterans, Am. J. Roentgenol. **10**:189 (March) 1923.

5. Goldthwait, J. E.: The Variations in the Anatomic Structure of the Lumbar Spine, J. Orthop. Surg. **2**:416 (July) 1920.

6. Marshall: A Case of Anomalous Spinal Development, J. Bone & Joint Surg., January, 1925.

7. Brackett, E. G.: Low Back Strain, J. A. M. A. **83**:1068 (Oct. 24) 1924.

and the first sacral vertebra; increased angle at the lumbosacral junction, and increased obliquity of the sacrum (toward the horizontal plane).

It has been reported that 50 per cent. of persons who do not suffer from backache have some irregularity or asymmetry in these regions, and an even greater percentage is found among persons who do suffer from backache. Willis,[8] after an examination of 850 spinal columns and referring to defects of the last presacral vertebra and to anomalies of the articular processes between the last lumbar vertebra and the

Fig. 1.—Sacralization of one of the transverse processes of the fifth lumbar vertebra. This was discovered accidentally as the patient presented no symptoms referable to the condition.

sacrum, states that the frequency with which defects were found in all cases and demonstrated among subjects requiring relief from back symptoms signifies a close relation between the existence of the defects

8. Willis, T. A.: Backache from Vertebral Anomaly, Surg., Gynec. & Obst. **38**:658 (May) 1924.

and the clinical evidence of disability. He further states that the fact that the defects are frequently demonstrated where no symptoms exist, and that the symptoms usually follow more or less severe trauma, would indicate that the defects are the predisposing, rather than the direct, cause of trouble. In proof of the latter statement, Willis [9] found that in a series of 100 roentgenograms taken for the diagnosis of low back pain, a split process defect was present in 10 per cent.; while in 850 anatomic specimens examined, it was found in only 1.2 per cent.

Attempts have frequently been made to link up certain types of deformity with definite clinical symptoms, but this has not always been possible.

ANOMALIES OF TRANSVERSE PROCESSES

Most of the painful conditions assumed to be due to anomalies of transverse spines concern the lateral processes of the fifth lumbar vertebra. Bauman,[10] however, calls attention to the frequent elongation of the third lumbar transverse process, especially in women, and finds that it can sometimes be palpated. He, moreover, describes and pictures the intimate contact between the lumbar and lumbosacral nerve trunks and the transverse processes of all the lumbar vertebrae, and demonstrates how easy it would be by rotation, malformation, etc., to get pressure on the nerve trunks and, consequently, pain. He suggests the name lumbosacral neuritis for this condition. The transverse process is not always the cause of pressure: In one operative case, Bauman found a tight thread of fibrous tissue spanning the nerve; and in another, a small nest of bony tissue was removed from one of the nerve trunks.

The anomalies of the lateral processes of the fifth lumbar vertebra vary from a simple departure from ordinary length, size and shape, to fan shaped and fish-tail shaped processes and to sacralization. These anomalies have been classified into groups by Richard.[11]

Sacralization of the fifth lumbar vertebra is said to be present in 25 per cent. of all persons. Moore [12] examined 3,640 roentgenograms and found 117 cases of sacralization, and a dissection of ninety-two cadavers revealed six cases of this anomaly. The sacralization may be symmetrical or asymmetrical, complete or incomplete. The symmetrical is more common than the asymmetrical.

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9. Willis, T. A.: Lumbosacral Column in Man, Am. J. Anat. **32**:95 (July) 1923.

10. Bauman, G. I.: The Relation of Lesions of the Transverse Processes to Pain in the Back and Legs, J. Bone & Joint Surg. **5**:579 (July) 1923.

11. Richard, A. J.: Pain in the Lumbosacral Region Associated with Congenital Malformation of the Transverse Processes of the Fifth Lumbar Vertebra, Am. J. Roentgenol. **6**:434 (Sept.) 1919.

12. Moore, S.: On the Incidence of the Sacralized Transverse Process and Its Significance, Radiology **2**:287 (May) 1924.

Z. B. Adams, in 1910, is said to have been the first to suggest that abnormal processes might have pathologic significance in cases of so-called sciatic scoliosis, and since then their presence has been assigned as the cause of many cases of painful backs. Some observers believe that the presence of transverse process abnormalities facilitates the

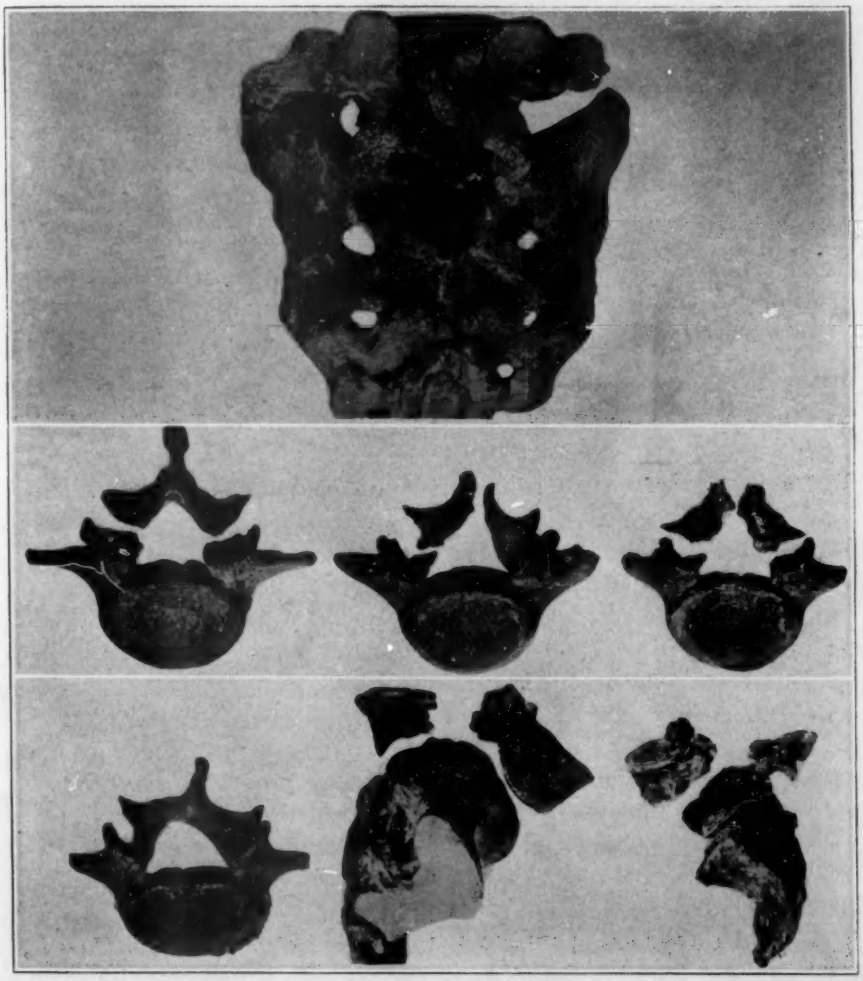

Fig. 2 (from Willis).—Seven types of neural arch defects which, by interfering with the normal attachments of ligaments, tend to weaken the strength and stability of the lumbosacral region.

production of slight traumatic displacements which leave behind them sprains; that they facilitate spondylolisthesis, and are sometimes the primary cause of scoliosis. Pressure of the enlarged or deformed transverse process on the sacrum is said sometimes to cause tilting of the

fifth lumbar and compensatory tilting of the sacrum, which causes strain on both sacro-iliac joints and subsequent pain and arthritis. The arthritis is said to be more marked on the side of the malformation.

The character of pain reported in the type of cases under discussion varies from indefinite aches to severe, sharp spasms, accompanied with marked muscle spasm. Richard concludes that the pain is due to the following causes:

1. Compression of soft tissue.
2. Irritation and arthritis of abnormal joints and bursae.
3. Slow acting strain on ligaments.
4. Pressure or tension of the segment of a nerve trunk.

Shackelton [13] believes that the factors involved in the production of pain are:

1. Impingement of the processes on the ilium, separating the sacro-iliac joints.
2. The transverse process acting as a fulcrum separating the lumbo-sacral joint.
3. Erosion of the ilium.
4. Hyperplasia of the surrounding tissues, including the nerve.

If all these causes of pain are correct, certainly the varying pain symptoms are justified. It must be admitted that at the present time there is no clear-cut pain symptom or clinical course for any particular transverse process abnormality. The nearest approach to a clinical entity seems to be cases described by Bauman: [14] in these cases, while the patient is lifting or under a strain something is felt to snap in the back, followed by sharp pain and weakness. A sciatica may develop and, subsequently, atrophy of the buttock, thigh and leg. Bauman believes that at the time of the "snap" in the back a rotation of the vertebra takes place, which causes a transverse process to press into a nerve trunk, causing pain. The pain is relieved by manipulation of the spine with, or sometimes without, an anesthetic. Cases with practically an identical history to that just described have been reported by other observers, but with a different diagnosis.

It has already been pointed out that transverse process abnormalities are frequently found in the roentgen-ray examination of cases in which there are no symptoms that would suggest their presence (Fig. 1). Bauman compares this late appearance of pain to cases of cervical rib, and another writer explains the late appearance of pain by the fact

13. Shackelton, W. E.: Some of the Surgical Aspects of Painful Back, J. A. M. A. **66**:1600 (May 20) 1916.

14. Bauman, G. I.: Spondylolisthesis, Am. J. Roentgenol., March, 1924.

that the union of the segments of the sacrum does not occur until the twenty-fifth year. These are explanations which do not explain.

Moore [12] reports that while only about 30 per cent. of persons seem to have transverse process abnormalities, the percentage of persons with back symptoms among those known to have abnormalities is 61 per cent. This would seem to indicate that the abnormalities are at least predisposing to pain.

Fig. 3.—Anterior posterior aspect of lumbosacral region in which articular facets between fifth lumbar vertebra and sacrum have a normal angle. The plane of the articulation of the facets does not show in this view. The position of the articular processes is indicated by arrows.

Many patients have been operated on and reports made of good results. Davis [15] reports ten cases of removal of fractured transverse

15. Davis, G. G.: Fracture of the Transverse Processes of the Lumbar Vertebrae, Surg., Gynec. & Obst. **33**:272 (Sept.) 1921.

processes with good results. Shackelton reports the successful removal of transverse processes by himself and others. Fassett reports three cases. Bauman reports eighteen cases, fourteen of which were cured, three improved and one unimproved. He reports more good results in a later article,[16] and states that the sciatic pain present was relieved in nearly every case.

The relief of cases by operative procedures is certainly a strong argument that the diagnosis was correct; but in the present state of knowledge, the only justifiable conclusion is that there is still considerable difference of opinion as to whether the symptoms associated with abnormal transverse processes are really due to their presence. It would certainly be unwise to make the diagnosis unless all other possible causes of lumbosacral pain had been excluded.

As regards treatment, one thing at least is clear: individuals known to have transverse process defects should avoid strenuous occupations, violent games, etc. When the diagnosis is believed to be correct, conservative measures, such as rest, avoidance of strain and support, should be tried first. Operation may be considered when all other measures fail. The transverse process may be removed or, in the case of impingement against the ilium, it may be of greater advantage to remove a portion of the ilium itself.

NEURAL ARCH DEFECTS

Willis [8] describes and pictures seven types of neural arch defects as follows (Fig. 2):

1. Central defect.
2. Bilateral laminar defect.
3. Central and right laminar defect.
4. Central and bilateral laminar defect.
5. Right laminar defect alone.
6. Complete separation of neural arch in twenty-fourth presacral vertebra. Spondylolisthesis, with consequent leveling of the anterior portion of the superior surface of the sacrum.
7. Complete separation of the neural arch in the twenty-fifth presacral vertebra. Spondylolisthesis, with consequent leveling of the upper aspect of the sacrum.

These abnormalities are more common in the male than in the female.

It is doubtful if any of these defects in themselves cause pain or symptoms, but in the bilaterally separate arch there is acute sensitiveness

16. Bauman, G. I.: The Cause and Treatment of Certain Types of Low Back Pain and Sciatica, J. Bone & Joint Surg. **6**:909 (Oct.) 1924.

to pressure directly on the spinous process. In old standing cases, this process may be moved from side to side by the examiner.

The strength and stability of the lumbosacral region depends very largely on ligaments, and if the normal attachment for ligaments is interfered with, there must neces arily follow a weakening of the support. Considered from this standpoint, neural arch defects undoubtedly predispose to strain, and in confirmation of this Willis reports that in

Fig. 4.—Same patient as shown in Figure 3 rotated to the left one-third the distance toward a full lateral position. Position of articular facets between fifth lumbar vertebra and sacrum on left side is indicated by arrows, the joint lying between the two arrow points. It will be seen that the joint is beginning to open up, i. e., the plane of the articulation more nearly comes into the direct line of the roentgen rays or vision.

100 roentgenograms of patients who complained of low back pain, occult spina bifida was found in 8 per cent. This is a much more frequent finding than in the anatomic laboratory.

DEFECTS IN THE ARTICULAR FACETS BETWEEN THE FIFTH LUMBAR VERTEBRA AND THE SACRUM

The body of the last lumbar vertebra is apposed to the upper surface of the sacrum at a considerable angle, so that if it were not for the articular processes between them the trunk would be held from slipping off the pelvis only by ligaments. It is extremely important, therefore, that the articular facets occupy the position of greatest strength and stability, and this condition exists when the plane of the articulation lies vertically and extends outward and backward from the sagittal plane of the body at an angle between 45 and 90 degrees.

It has been found that the position of the facets varies greatly. The anterior-posterior plane of the articulation may run anywhere from vertical to horizontal, and the lateral plane may lie anywhere from an angle of 90 degrees to parallel with the sagittal plane of the body. In a large percentage of cases, the two sides do not articulate at the same angle, so that if, as sometime happens, there is a perpendicular facet on one side and a horizontal one on the other, rotation of the spine occurs toward the perpendicular, or fixed, side. In some cases of defective articulation, a spondylolisthesis may be produced. Bony deformities are more easily produced if the ligaments are relaxed.

The abnormalities in the articular processes have been found mostly in anatomic laboratories, and up to the present time there has been no definite technic established for locating the position of the facets in the living subject. I believe it is now possible to do this.

When conditions are normal, the ordinary anterior posterior roentgenogram, either singly or stereoscopic, fails to show the articular plane of the facets, and a direct lateral roentgenogram also is useless for diagnosis. The manner of showing the articular facets is as follows: The usual anterior posterior roentgenogram is made with the patient lying on the back and the tube centered in the midline, a little below the level of the anterior superior spines. With the facets in a normal position, they cannot be made out in this roentgenogram (Fig. 3). The patient is now rotated, say to the left, about one third the distance toward a direct lateral position, and a second roentgenogram made. If the facets are normal, the left articulation will begin to open up (Fig. 4). If the articulation completely opened up in this position, it would mean that it formed an angle with the sagittal plane of the body of about 30 degrees. The patient is now rotated to about two thirds the distance

toward a direct lateral position, and a third roentgenogram is taken. If the facets approximate the normal, the articulation will now open up still more (Fig. 5), corresponding to an angle of about 60 degrees with the sagittal plane of the body. By comparing the appearance of the articulation in the different roentgenograms, the angle made with the sagittal plane of the body can be computed fairly accurately (Fig. 6), and any tilting of the joint from the vertical can easily be made out and estimated (Figs. 7 and 8).

Fig. 5.—Third view of patient shown in Figures 2 and 3 rotated to left about two-thirds the distance toward a full lateral position. Position of articular facets between fifth lumbar vertebra and sacrum on left side is indicated by arrows, the joint lying between the two arrow points. The joint is now completely opened up; or, in other words, the plane of the articulation is now such that the roentgen rays pass directly through it. This indicates that the line of articulation approximates 60 degrees with the sagittal plane of the body and, as can be seen, also runs vertically. This articulation, therefore, is normal.

When conservative treatment of a low back pain has failed, and it has been definitely established that the articular facets between the fifth lumbar vertebra and the sacrum are defective, and other causes have been ruled out, it is perfectly justifiable to operate and to ankylose the articulations.

THE LUMBOSACRAL JUNCTION

Lackum [17] calls attention to the fact that the lumbosacral joint is an unstable mechanism for the following reasons:

1. It is the junction of a mobile and immobile part.

2. The usual means of joint stabilization are at a disadvantage in consequence of a developmental structure designed for the all-four position.

3. It is the site of a rotating action which is often asymmetrical.

4. It is the site of tremendous shearing strain.

There is always a tendency to strain at the lumbosacral joint, because the angle of junction is such that a shearing strain is present in any position. Backache may be the result of prolonged normal strain which cannot be controlled by weakened muscles, or the angle may be greater than usual, which increases the strain. Also, should the articular facets be defective, or should there be loss of bone interfering with the attachment of ligaments, the tendency for strain is greatly increased.

Whitman [18] describes a small series of cases in which the angle between the spine and the sacrum is increased and causes pain. He suggests the name "prespondylolisthesis."

Various studies of the lumbosacral region in reference to the angle usually present have been made, but most of the research has been done in anatomic laboratories. This point can now be determined in the living subject by the use of a Bucky diaphragm and a penetrating roentgen-ray. The roentgenograms are taken laterally with the patient standing.

The spine rests on the sacrum, being held in position by the articular processes between the fifth lumbar vertebra and the sacrum, the ligaments and the muscles. If the upper surface of the sacrum were parallel to the horizon, there would be little strain at the lumbosacral junction in the upright position; but this is not so. The upper surface of the sacrum is inclined downward and forward, the average angle being about 42 degrees. Any increase of this angle naturally would increase strain; therefore, this angle should be determined in all cases. Another factor

17. Von Lackum, H. L.: The Lumbosacral Region, J. A. M. A. **82**:1109 (April 5) 1924.

18. Whitman: Observations Upon an Anatomic Variation of the Lumbosacral Joint, J. Bone & Joint Surg. **6**:808 (Oct.) 1924.

influencing strain is the angle at which the fifth lumbar vertebra joins the sacrum. If the under surface of the fifth lumbar vertebra were parallel to the upper surface of the sacrum, the resulting shearing strain would be represented by a vertical line projected against a 42 degrees angle; but if, as usually happens, the under surface of the fifth lumbar vetebra is apposed to the top of the sacrum less away from the horizontal than the upper surface of the sacrum, then the greater this angle the greater would be the tendency for the spine to slip off the sacrum, and, consequently, the greater the shearing strain. A record

Fig. 6.—Anterior posterior view of lumbosacral region. Position of articular facets between fifth lumbar vertebra and sacrum on one side is indicated by arrows, the joint lying between the two arrow points. The plane of the articulation presents almost directly forward, i. e., parallel to the sagittal plane of the body. Such an articulation is defective, and the strain of keeping the fifth lumbar vertebra from slipping off the sacrum would fall almost entirely on ligaments.

of this angle (the normal average of which seems to be about 10 degrees) should be made in all cases. The shearing strain may then be indicated by the angle that the top of the sacrum makes with the horizontal plus the angle between the bottom of the fifth lumbar vertebra and the top of the sacrum (normal shearing strain = 42 degrees plus 10 degrees) (Fig. 9).

The anterior upper edge of the sacrum is sometimes built up under the fifth lumbar vertebra. This should be noted in every case, since, when present, it tends to diminish the shearing strain.

In the last analysis, the strength and integrity of the lumbosacral region depend on ligaments, and any bony abnormality that interferes with ligamentous attachment or that increases the angles in the lumbosacral region is not only a predisposing factor to strain, but also an element in keeping up strain, once that condition arises.

When a painful back is thought to be due to an increased shearing strain at the lumbosacral junction, conservative treatment in the form of avoidance of strain and the use of supports should be tried. This failing, an operation of bony fusion, which has apparently proved satisfactory when properly performed, is justifiable.

ACUTE AND SUBACUTE CONDITIONS WITHOUT TRAUMA

The pains and aches of an acute febrile disturbance, probably toxic in origin, seem to center in the lower back in some persons, and because of the lowered tone may persist for some time. Magnuson [19] is of the opinion that toxemias cause just as many, if not more, low back pains than do infections.

Myalgia (lumbago) may occur as the result of exposure to cold, trauma, etc.

Toxemias from focal infections would seem to be definitely proved as a cause of backache.

Some of the diseases that may be the cause of pain in the back are osteomyelitis, infectious arthritis, typhoid fever, gonorrhea, tuberculosis, syphilis and neoplasms. The diagnosis of these conditions is made by the history, special tests and roentgen-ray examinations. A condition that should always be borne in mind as a possible cause of pain in the back is cord tumor. All doubtful cases and cases in which there are any sensory or motor disturbances should be subjected to a thorough neurologic examination.

Trauma.—Every patient with injury to the back should have a roentgen-ray examination as soon as possible. The results of this examination

19. Magnuson, P. B.: Reasons for Lack of Positive Roentgen Findings in Many Cases of Low Back Pain, Am. J. Roentgenol. **12**:15 (July) 1924.

may show at once a fracture or dislocation, and proper treatment can be promptly instituted. Occasionally, a case of back injury may be negative to roentgen-ray examination at the time of injury; later, symptoms suggesting tuberculosis of the spine may develop, and a small kyphosis may appear. A roentgen-ray examination made at this time will show crushing together of the bodies of one or more vertebrae. These are cases of the so-called Kümmel's disease.

Fig. 7.—View of lumbosacral region of a patient rotated toward left side about two-thirds of the distance toward a full lateral position. The position of the articular facets between the fifth lumbar vertebra and the sacrum on the left side is indicated by arrows, the joint lying between the two arrow points. The planes of the articulation will be seen to be normal.

When the roentgen-ray examination is negative or shows only some bony abnormality, as previously described, the trouble may be a strain or sprain of the lumbosacral or sacro-iliac region. Sacro-iliac strain is a favorite diagnosis at present; on the other hand, some orthopedic men

practically deny the existence of sacro-iliac dislocation, subluxation or strain. In many cases, there undoubtedly is no warrant for a diagnosis of sacro-iliac strain and, except in severe crushing injuries, the diagnosis of sacro-iliac dislocation, which is sometimes made, is absurd. Theoretically, there seems to be no reason why there should not be cases of sacro-iliac strain. In the standing position, the sacrum is suspended between the ilia, and is held in position only by ligaments and the pressure of the ilia against the roughened surfaces of the sacro-iliac joints. If the ligaments supporting the sacrum were cut away and the pelvis subjected to a wrench or strain, the sacrum would fall forward into the pelvic cavity. Moreover, the sacro-iliac joints have been shown to be true joints, with articular cartilage and ligaments. They are subject to inflammation and infection the same as other joints, and the obstetricians have definitely proved that, under certain conditions, they do move. Smith-Petersen [20] and others report relief of pain by an ankylosing operation in cases they have diagnosed as sacro-iliac strain.

Magnuson [21] believes that subluxation of the sacro-iliac joints occurs, and he describes the mechanism as follows: If the ligaments are relaxed through a condition such as loss of tone or a low grade inflammation, when the patient stoops forward there may be a slight slip of the sacrum forward on the roughened joint surface at the upper level. There is an acute pain in the back, due to the overstretch of ligaments, and because of this pain a muscle spasm immediately occurs. On account of the pain and muscle spasm, the patient is unable to straighten up, and the sacrum is unable to slip back into place because of the roughened area of the joint. The displacement is, of course, very slight, and will not show in a roentgenogram. The pain and disability disappear on manipulation.

Whether or not one accepts Magnuson's explanation of cases of the character described, one cannot but agree with Brackett when he says: "It is hardly to be questioned that these strains are due to a giving way of some of the ligamentous structures about the articulations." This would apply to strains both of the lumbosacral and sacro-iliac regions.

Many cases are associated with sciatic pain. The accepted explanation of sciatic pain is that a traumatic inflammation occurs in the ligaments; this produces a swelling and inflammation in the surrounding tissues that is transmitted to the nerves. Danforth and Wilson,[22] in a

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20. Smith-Petersen, M. N.: J. Orthop. Surg. **3**:400 (Aug.) 1921.

21. Magnuson, P. B.: Abnormalities of the Fifth Lumbar Transverse Process, Bull. Chicago M. Soc., May 27, 1922.

22. Danforth and Wilson: The Anatomy of the Lumbosacral Region in Relation to Sciatic Pain, J. Bone & Joint Surg., January, 1925.

recent investigation, have studied sciatic pain of this type from four standpoints, viz., anatomic, clinical, neurologic and roentgenologic examinations, and they believe that the site of the lesion is most frequently the lumbosacral region. Associated with the sciatica there may be a list of the trunk (sciatic scoliosis), loss of tendon reflexes, and atrophy in the gluteal region, thigh and calf.

Treatment varies with the severity of the case. First of all, too strong emphasis cannot be placed on a thorough treatment of the

Fig. 8.—Lumbosacral region of same patient as shown in Figure 7 rotated to the right two-thirds the distance toward a full lateral position. The position of the articular facets between the fifth lumbar vertebra and the sacrum on the right side is indicated by arrows, the joint lying between the two arrow points. It will be seen that, while the angle of the line of articulation with the sagittal plane of the body is normal, it does not run vertically but is inclined backward nearly 45 degrees. This joint is therefore defective.

original injury. The patient should have rest in bed and freedom from strain of any sort until the symptoms have disappeared. The relief of pain may be hastened by the use of radiant heat on the back and also

by adhesive strapping. In strapping a back for this condition, the most efficient and comfortable form of strapping has been found to be 2 inch wide (5 cm.) adhesive straps which are applied circularly around the body, but which leave the front of the abdomen free. They extend from the level of the trochanter of the femur to the dorsal region of the spine. After the first layer of circular straps has been applied, a vertical layer is put on, and this in turn is followed by another circular layer. If the case does not clear up promptly, or if there is any tendency to recurrence, the patient should wear a support (Fig. 10) and be warned against the strain of lifting or of working in a bent over position. Sciatica should be treated by rest in bed and a Buck's extension. If "sciatic scoliosis" is present and a Buck's extension will not clear it up, it may be necessary to give the patient an anesthetic, to reduce the deformity and to apply a plaster cast (hip spica) until pain and disability have ceased. The patient should then be fitted to a support and warned against strain. When conservative treatment, as here outlined, has failed, the only logical thing to do is to fix the part by a bony union.

Patients that have had a lumbosacral or sacro-iliac strain should be careful as to what work they do because they are very apt to have subsequent attacks, especially if bony abnormalities are present. Brackett,[7] referring to these cases from an industrial standpoint, says, "The advisability of employing these men indiscriminately for labor is debatable."

Such, in brief, is an outline of the various painful conditions of the lumbar, lumbosacral and sacro-iliac regions. It is easy to understand the difficulties of diagnosis, but the inability to make a diagnosis is often due in part to a poor technic and to a lack of attention to detail in the clinical history and examination, and in part also to a lack of cooperation with the roentgenologist in determining what is normal and what is pathologic. There seem to be no absolutely definite characteristic symptoms or signs that serve to differentiate the various conditions one from the other, but the whole history and examination must be carefully analyzed and a balance of all the factors taken before a diagnosis is attempted. This necessitates a systematic method of history taking and examination. Smith-Petersen,[23] in recent articles, discusses his method of history taking and examination as an aid to differentiating between lumbosacral strain and sacro-iliac strain, and his ideas have been incorporated in the following questionnaire and examination blank.

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23. Smith-Petersen, M. N.: Routine Examination of Low Back Cases with Particular Reference to Differential Points Between Lumbosacral and Sacro-Iliac Regions, J. Bone & Joint Surg. **6**:819 (Oct.) 1924; Clinical Diagnosis of Common Sacro-Iliac Conditions, J. Bone & Joint Surg., January, 1925.

QUESTIONNAIRE

Name Age
Complaint
What is the situation and character of your pain?
Any referred pain?
How long have you had pain?
Describe the onset of your pain
What seems to intensify your pain?
What is your most comfortable position?
What is the condition of your back in the morning as regards pain and stiffness?
Have you pain in any other joints?
Question patient as to symptoms of weak feet
If patient is a woman, question as to gynecologic history
- Is pain worse at menstruation?
- Was pain affected by child-bearing?

Genito-urinary history
Medical history
- Is there marked constipation?
- Has patient a marked nervous or neurotic temperament?
- Do the symptoms suggest spinal inefficiency?
- Is the patient suffering from or has he ever had any disease that might be associated with pain in the back, such as:
  - Fevers
  - Myalgia
  - Osteomyelitis
  - Infectious arthritis
  - Focal infection
  - Gonorrhea
  - Typhoid fever
  - Tuberculosis
  - Syphilis
  - Neoplasms
  - Cord tumors?

EXAMINATION

Standing
- Walk
- Examination of feet for foot strain
- Posture and spine
  - Does the trunk list to one side?
  - Which side?
  - Motions

Flexion .....
- Normal .....yes.....no
- Muscle spasm.....yes.....no
- Painful .....yes....no
- Character of bending

Extension .....
- Normal .....yes.....no
- Muscle spasm.....yes.....no
- Painful .....yes....no
- Character of bending

Lateral bending.....
- Normal ..... Right.....yes.....no; Left.....yes.....no
- Muscle spasm..... Right.....yes.....no; Left.....yes.....no
- Painful ..... Right.....yes.....no; Left.....yes.....no
- Character of bending.. Right / Left

Sitting

Flexion forward....
- Normal .....yes.....no
- Muscle spasm.....yes.....no
- Painful .....yes.....no

Lying
- Inspection
  - Atrophy.....yes.....no
    - Situation and amount
- Palpatio
  - Sensitive inferior sacro-iliac ligament..... Right .....yes....no; Left .....yes....no
  - Sensitive sacrosciatic notch..... Right .....yes....no; Left .....yes....no
  - Sensitive sciatic nerve..... Right .....yes....no; Left .....yes....no
  - Sensitive ilio-lumbar ligament..... Right .....yes....no; Left .....yes....no
  - Sensitive spinous processes and interspinous ligaments.....yes....no
    - Which processes and ligaments
  - Sensitive dorsum of sacrum.....yes....no
  - Sensitive articular facets between fifth lumbar vertebra and sacrum..... Right side....yes....no; Left side....yes....no
  - Sensitive transverse processes.....yes....no
    - Which transverse processes

Rectal Examination
Condition of prostate
Motions
Passive flexion of lumbar spine: Normal ....yes....no; Muscle spasm....yes....no; Painful ....yes....no
Passive extension of lumbar spine: Normal ....yes....no; Muscle spasm....yes....no; Painful ....yes....no
Special tests
Straight leg raising, Right side: Normal ....yes....no; Muscle spasm....yes....no; Painful ....yes....no; Pain before lumbar spine moves....yes....no
Straight leg raising, Left side: Normal ....yes....no; Muscle spasm....yes....no; Painful ....yes....no; Pain before lumbar spine moves....yes....no
Compression of crests, painful: Lying on right side....yes....no; Lying on left side....yes....no
Compression of pubis, painful....yes....no
Urinary examination
Roentgen-ray examination
Summary and diagnosis

ANALYSIS OF EXAMINATION

Complaint.—There is nothing in the complaint of the patient that is particularly characteristic of the various conditions. Pain in the back or pain and stiffness in the back is the most common complaint. Sometimes the patient complains of pain running down the leg (sciatica).

Situation and Character of Pain.—An analysis of the situation and character of the pain complained of seems to have only a limited bearing on diagnosis. It would seem, however, that the dull, heavy pains are more apt to be associated with chronic conditions, and the sharp stabbing pains with acute trouble. The situation of the pain is usually a fairly good index as to where the trouble is located.

Referred Pain.—Smith-Petersen has made a careful analysis of the differences in referred pain in lumbosacral and in sacro-iliac conditions. In lumbosacral strains, he finds pain referred to the anterolateral and posterior aspects of the lower leg and to any part of the foot. In sacro-iliac cases, pain may be referred to the posterior aspect of the thigh, as well as to any part of the lower leg. The type of pain most commonly found, however, is pain referred to the posterior aspect of the thigh, anterolateral and posterior aspects of the lower leg and lateral aspect of the ankle. Pain may be referred to the sacro-sciatic notch. Occasionally, the pain is referred to the inferior mesal aspect of the thigh.

Duration of Pain.—Knowledge as to the duration of pain is of value in determining whether a condition is acute, subacute or chronic.

Onset of Pain.—This item is of great importance as an aid to diagnosis. If the pain and disability follow directly after a trauma, then in

all probability trauma is the cause, and the examiner would expect to find dislocation, fracture or strain. Those cases in which the patient gives a history of feeling something give way in the back (sometimes a snapping), followed by sharp pain and decided weakness, have been diagnosed in various ways by different observers. The most reasonable diagnosis would seem to be a tearing of a ligament followed by strain. Smith-Petersen believes that the type of trauma makes a difference as to the lesion. Thus, leverage transmitted through the hamstrings uni-

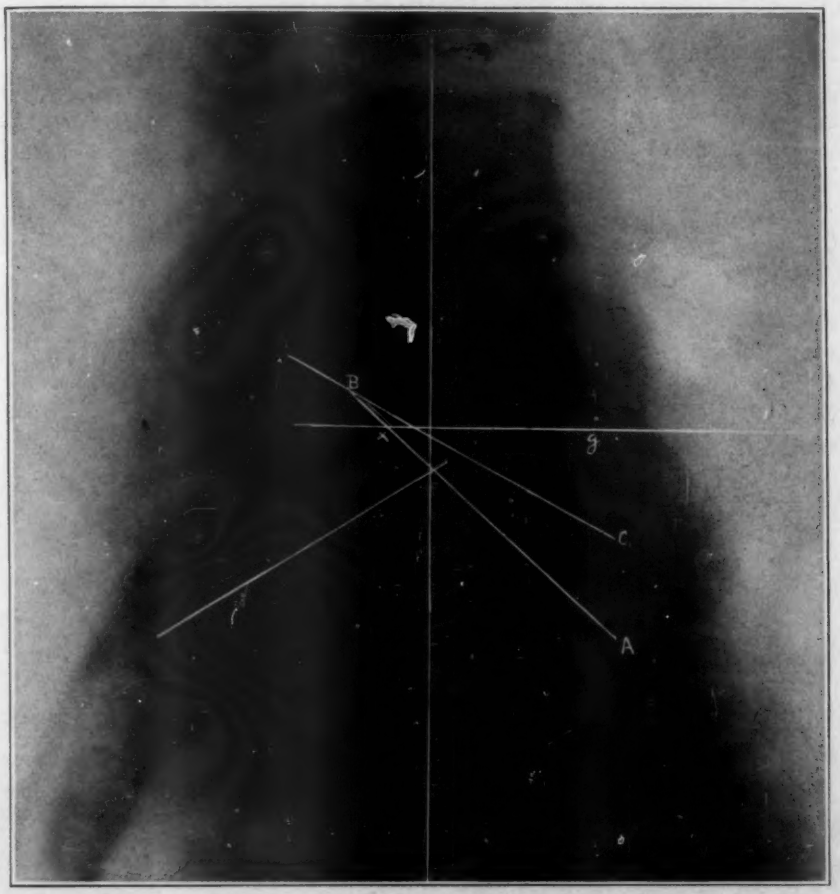

Fig. 9.—Lateral view of lumbosacral region of patient standing. *XY*, line parallel to horizon; *AB*, upper surface of the sacrum; *AXY*, angle that upper surface of sacrum forms with horizontal (in this case, 42 degrees); *BC*, lower surface of fifth lumbar vertebra; *ABC*, angle at which lower surface of fifth lumbar is opposed to upper surface of sacrum (in this case, 12 degrees). The shearing strain in the lumbosacral region in this particular case, therefore, would be represented by angle *AXY* (42 degrees) + angle *ABC* (12 degrees).

laterally to the pelvis is more apt to cause a sacro-iliac condition, while a leverage applied from above with the spine in a position of flexion is more apt to affect the lumbosacral region. If the painful condition affects a woman and she dates her trouble from the last months of pregnancy or directly after childbirth, the chances are that there is a relaxation of the ligaments holding the pelvis. If the pain and disability can be traced back to an attack of fever, or if it followed a known focal infection, the trouble is probably a toxemia. Following an exposure to cold, a myositis would be suspected, and numerous other examples could be cited in which the history of the onset of pain would be a very good indication of the trouble.

Intensification of Pain.—In genito-urinary conditions, the back pain can sometimes be directly associated with urinary symptoms. In neurotic conditions, increased nervousness is always followed by increased pain. In cases in which the painful condition is due to constipation, increased constipation means increased pain. If the painful back is due to weak feet, walking or standing intensifies the pain, and in chronic occupational strains, a period of work is always followed by increased pain. In tuberculosis and neoplasms of the spine, a jar, wrench or unguarded movement causes acute pain. In lumbosacral and sacro-iliac strains, working in a bent over position or lifting are almost sure to increase the trouble. Coughing, sneezing or straining at stool aggravates the pain in acute sacro-iliac conditions.

Most Comfortable Position.—Smith-Petersen says a lumbosacral patient can be made comfortable on either side or on the back, while a sacro-iliac patient, as a rule, cannot lie for any length of time on the side of which complaint is made. In chronic strains of the lumbosacral region, the patient seems to be more comfortable with a small pad under the hollow of the back when lying down, or behind the back when sitting.

Condition of the Back in the Morning.—In diseases of the spine, rest in bed seems to benefit the condition; but in chronic strains, the back is apt to be worse in the morning than at night.

Pain in the Other Joints.—The presence of pain in other joints suggests rheumatism, infectious arthritis or ostearthritis.

Weak Feet.—With symptoms suggesting weak feet and a history that backache increases with standing and walking, it is very probable that the weak feet are the cause of the backache.

Gynecologic History.—If the history is at all suggestive of gynecologic trouble, a thorough gynecologic examination should be made. An increase of pain at the time of menstruation suggests chronic strain, as the ligaments are apt to relax at that time. Likewise, increase of pain during pregnancy or after childbirth has the same explanation.

Genito-Urinary History—Any genitó-urinary symptoms should be followed up by careful urine, roentgen-ray and other examinations.

Cord Tumors.—If there is any loss of sensation, abnormal reflexes, muscular weakness or ataxia, the patient should be subjected to a thorough neurologic examination in order to rule out any organic disease of the nervous system.

EXAMINATION

Walk.—In tuberculosis of the spine with psoas abscess, the patient may walk with a limp due to psoas contraction. In sacro-iliac strain, the patient is inclined to take short steps and to keep the weight off the affected leg.

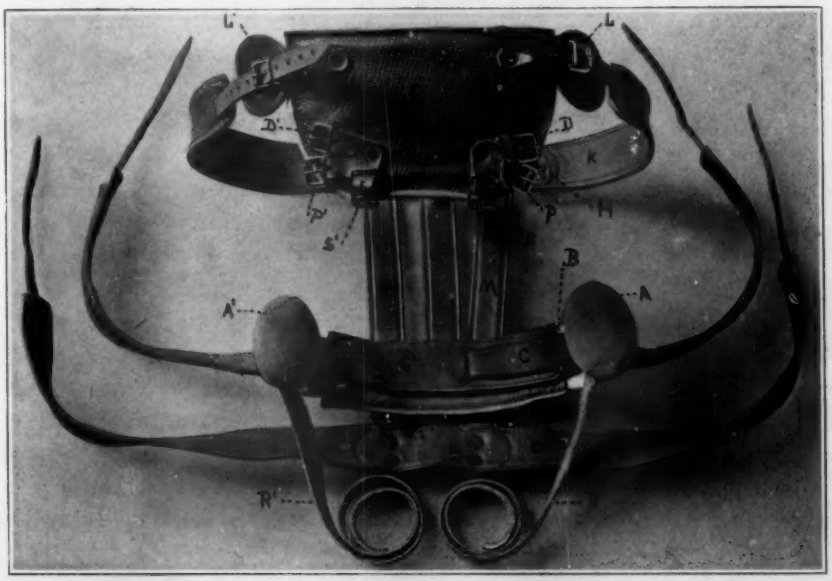

Fig. 10.—Support described by writer in *Surgery, Gynecology and Obstetrics* for June, 1923. The pads, *A* and *A'*, give lateral support to the pelvis, and this form of brace has proved especially useful in true sacro-iliac cases. In the picture, the abdominal pad has been raised in order to allow the detail of the lower part of the support to be seen.

Posture and Spine.—The presence or absence of a large abdomen and increase or decrease of the normal lumbar curve should be noted. In spondylolisthesis and in so-called "prespondylolisthesis," there is an increased angle between the lumbar spine and the sacrum.

Listing of Trunk.—A list of the trunk may be present in both lumbosacral and sacro-iliac cases, and is more apt to be away from the affected side in lumbosacral cases. In sacro-iliac conditions, a list away from the affected side is usual in acute cases and is an effort to eliminate

weight bearing. The explanation of a list toward the affected side, which sometimes occurs, is to keep the surfaces of the joint in contact and to prevent leverage on the sensitive joint.

Flexion of the Spine Standing.—In lumbosacral conditions, muscle spasm is apt to keep the lumbosacral region rigid, and forward bending takes place at the hips and in the upper spine. In sacro-iliac conditions, the patient is apt to bend forward first by flexion of the lumbar spine and then by tilting the pelvis until the hamstrings become taut. At this point the patient either stops because of pain or flexes his knee on the affected side so as to relax the hamstrings, and then is able to bend over farther. Bauman, referring to the painful condition that he believes due to pressure of transverse processes against nerve trunks, says, "Limitation of motion and muscle spasm are usually found in these cases, but they are so variable that no great reliance may be placed on them in making a diagnosis."

Extension of the Spine Standing.—In lumbosacral conditions, the patient is apt to keep his lumbar spine rigid and to bend backward by bending the knees, and there is little or no motion in the lumbosacral region. In sacro-iliac conditions, however, there is distinct motion in the lumbar spine, and the pelvis tilts backward. The motion is performed relatively freely.

Lateral Bending Standing.—In lumbosacral strain, there is very little motion at the lumbosacral junction, the movement takes place in the dorsal and upper lumbar spine. Motion away from the affected side is usually the freer. In acute sacro-iliac cases of an inflammatory nature, motion is more limited toward the affected side than away from it. In sacro-iliac strain, however, the patient is trying to keep the joint surfaces approximated and bends more freely toward the side affected.

Flexion Forward Sitting.—The patient bends forward easily in sacro-iliac cases, but the motion is limited in lumbosacral conditions.

Atrophy.—Atrophy of the gluteal region, the thigh and even of the calf may be found in all chronic cases in which the nerves have been involved, but would seem to be more marked in sacro-iliac cases.

Palpation.—The diagnostic points of palpation as described by Smith-Petersen are of great value:

Sensitive inferior sacro-iliac ligaments are in favor of sacro-iliac strain.

A sensitive sacro-iliac notch is in favor of sacro-iliac strain. This is almost a constant finding.

A sensitive sciatic nerve may be found in both sacro-iliac and lumbosacral cases.

Sensitive iliolumbar ligaments are in favor of lumbosacral strain.

Sensitive spinous processes and interspinous ligaments may be found in interlocking spinous processes, in diseased conditions, or in some abnormalities

of the neural arch. Whitman says that in cases of "prespondylolisthesis" the patient is sensitive to pressure in the midline of the lumbosacral joint.

In regard to sensitive transverse processes, Bauman lays great stress on the palpating of the transverse processes in locating processes that are causing nerve pressure. He emphasizes that in testing for a painful transverse process it is important to find the highest one so as to rule out referred pain. Pressure applied by the thumb over a transverse process causes an increase of pain which may last for several hours. This may be followed by a longer, also temporary, period of relief of pain. If a patient can be confused on the location of points of pain, one should be suspicious of a functional neurosis. This should apply to the examinations in all regions.

A sensitive sacrum and articular facets may be present in both lumbosacral and sacro-iliac conditions.

Rectal Examination.—Smith-Petersen says that in acute inflammatory conditions the swelling and tenderness can sometimes be palpated. A rectal examination is of value principally in ruling out such conditions as pelvic tumor and carcinoma of the prostate. The rectal examination sometimes reveals a sensitive tip of the coccyx.

Passive Flexion of the Lumbar Spine Lying.—In lumbosacral cases, passive flexion of the lumbar spine causes pain, and the lumbar spine cannot be flexed. In sacro-iliac cases, this motion is apt to be free.

Passive Extension of the Spine Lying.—This test is of no special diagnostic value, but there is more apt to be muscle spasm and pain in diseases of the spine and in lumbosacral cases than in sacro-iliac cases.

Straight Leg Raising.—Bauman says that in cases of neuritis in the leg, there is usually an increase in pain on straight leg raising, and that frequently the patient complains of pain in a certain spot in the lumbar region. He believes that this is due simply to stretching of the sciatic or lumbosacral nerves, and that it has little value in diagnosing the exact location of the trouble. Smith-Petersen believes that, if properly performed, straight leg raising is of considerable value in diagnosis. His method is as follows: While the leg is raised slowly with one hand, the other hand is held under the patient's lumbar spine. As the hamstrings tighten, leverage is gradually applied to that side of the pelvis. If pain is brought on before the lumbar spine begins to move, he believes that this is definitely in favor of a sacro-iliac condition. If however, pain does not come on until after the lumbar spine begins to move, this reaction is in favor of either a sacro-iliac or a lumbosacral condition. In raising the opposite leg, it is possible to bring it to a higher level without pain in sacro-iliac cases. In lumbosacral cases, the pain comes on at the same level with both legs.

Compression of the Crests.—Smith-Petersen has the patient lie on the unaffected side; he puts his forearm on the affected side and presses

down firmly for one half minute, if necessary. If this is positive for pain, it is in favor of acute sacro-iliac trouble; but if negative, it does not rule out sacro-iliac trouble.

Compression of the Pubis.—Painful compression of the pubis is in favor of sacro-iliac conditions.

Roentgen-Ray Examination.—The necessary roentgen-ray examinations already have been spoken of in discussing the various conditions.

CONCLUSIONS

Many factors enter into the diagnosis of low back pain, and it must be admitted that at the present time there is no one sign or symptom pathognomonic of a lesion affecting the lumbar, lumbosacral or sacro-iliac regions. The various diagnostic points mentioned are only suggestive, and do not hold true in every case.

Unless each case is studied with minute attention to detail, errors in diagnosis are almost certain. By constantly practicing a thorough and systematic examination, it undoubtedly will be possible gradually to clear up the confusion in signs and symptoms which now exists.

It has been demonstrated in this article that in the living subject it is now possible to show the situation and angle of the articular facets between the fifth lumbar vertebra and the sacrum. It is also possible to show the lumbosacral angle and the angle between the lower surface of the fifth lumbar vertebra and the upper surface of the sacrum. These factors have an important bearing on low back pain, and it is of great advantage to be able to determine them in the living subject.

THE SACROVERTEBRAL ANGLE, ITS MEASUREMENT AND THE CLINICAL SIGNIFICANCE OF ITS VARIATIONS

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AND
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The sacrovertebral angle is the angle formed between the sacrum and the last lumbar vertebra. That there is possible a standard for the measurement of its amplitude, that this measurement is subject to variation and that variation may cause low back symptoms, it is the endeavor of this paper to prove.

Improvements in roentgen-ray technic have made available to us the lateral view of the pelvis in which the relationships of the lumbar vertebrae and the sacrum are shown in sagittal section. While many films leave much to be desired in the matter of clearness and definition, yet even in poor films we have an aid not to be despised.

It is greatly to be desired that we find some way to correlate the reading of the lateral with the anteroposterior views of the same patient. This will be touched on later.

A film of a lateral roentgenogram of the lower back and pelvis will show in good definition, the first, second, third and part of the fourth lumbar vertebrae in men, and practically all of the fourth in women. From the level at which the iliac crests overshadow the vertebrae, the latter are hazy, yet there is enough definition to make their outlines moderately clear; the upper part of the sacrum is likewise overshadowed but discernible. Given a case without fracture, dislocation or bony overgrowth from spondylitis or other cause, we note that the lumbar vertebrae lie one above the other, presenting, as a group, an anterior convexity. At the lowest part of the lumbar spine is seen the promontory of the sacrum; this is made prominent by the sacrum being at an angle to the fifth lumbar vertebra, the so-called sacrovertebral angle. The clinical importance of variation in this angle is recognized, and several different methods have been devised for its measurement, but as yet no standard has met with universal recognition.

The method of measurement used by the writers is as follows: A lateral film of the lumbosacral region being placed in the view box, the shadow of the body of each vertebra is bisected vertically by a pencil mark (Fig. 1), a transparent ruler being used. The arms of a protractor are laid along, respectively, the mark indicating the vertical axis of the fifth lumbar and that of the sacrum, and the degree of angulation is

read on the scale. On films examined by us, the sacrovertebral angle was found to range from 128 to 160 degrees, the greater number reading from 148 to 155 degrees. Most of the patients seen having an angle below 145 degrees had back pain, but there were some with even an angle of from 130 to 135 degrees in whom there were no symptoms.

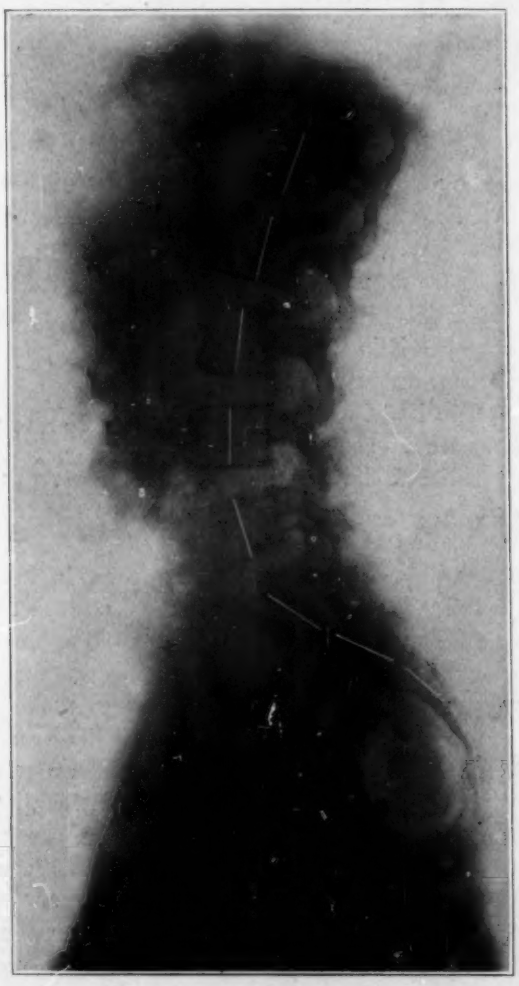

Fig. 1.—Lateral view of lumbar spine and sacrum, showing position of lines on which direct measurement may be made of sacrovertebral angle as well as those for measurement of angles between adjacent vertebrae.

The same lines used in measurement of the sacrovertebral angle of living subjects by means of the roentgenogram also were applied in the measurement of some forty cadaver sections of the sacrolumbar region

(in the anatomy laboratory of the University of Pittsburgh School of Medicine) with the following results (Fig. 2):

At 132 degrees angulation, there was one; at 135 degrees, there were two; at 138 degrees, three; at 140 degrees, one; at 145 degrees, four; at 148 degrees, two; at 150 degrees, six; at 152 degrees, one; at 155 degrees, fourteen; at 158 degrees, one; at 160 degrees, three; at 165 degrees, one, and at 168 degrees, one.

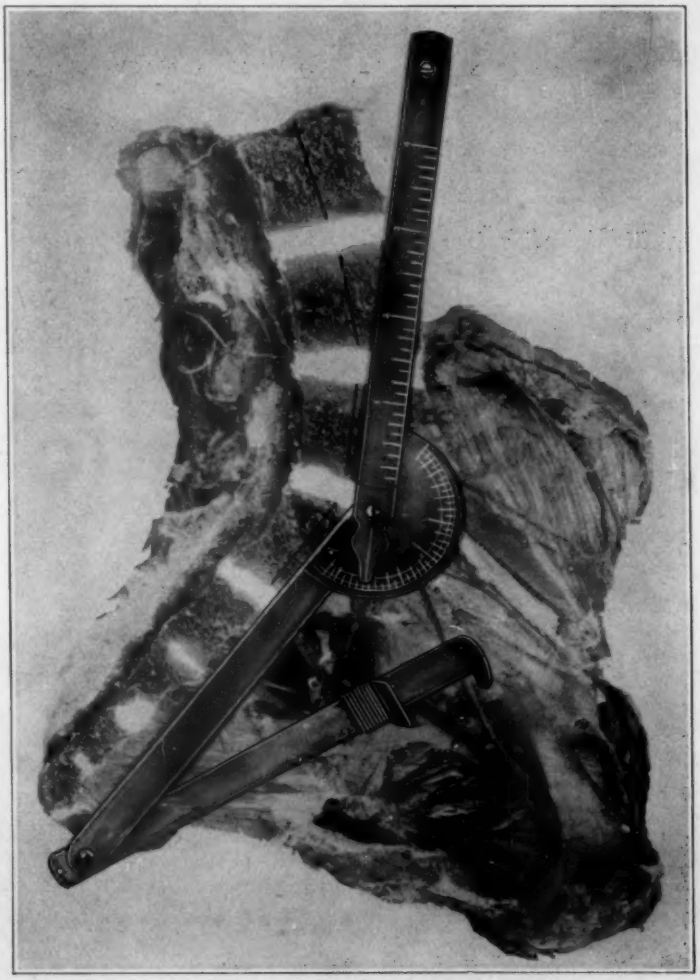

Fig. 2.—Direct measurement of sacrovertebral angle on cadaver specimen.

The foregoing measurements, taken alone, are not considered of much value, but, taken in connection with the readings of measurements taken on the same lines in lateral roentgenograms, they would seem to indicate that the most frequent angular relationship between the perpen-

dicular axis of the fifth lumbar and the sacrum is close to 155 degrees.

The protractor used is that previously described by one of us (W. H. R.[1]). Since its original description, the small caliper arrangement has been added to the arm on which is the millimeter scale. This is for convenience in measuring small diameters, such as roentgen-ray shadows and Pirquet reactions.

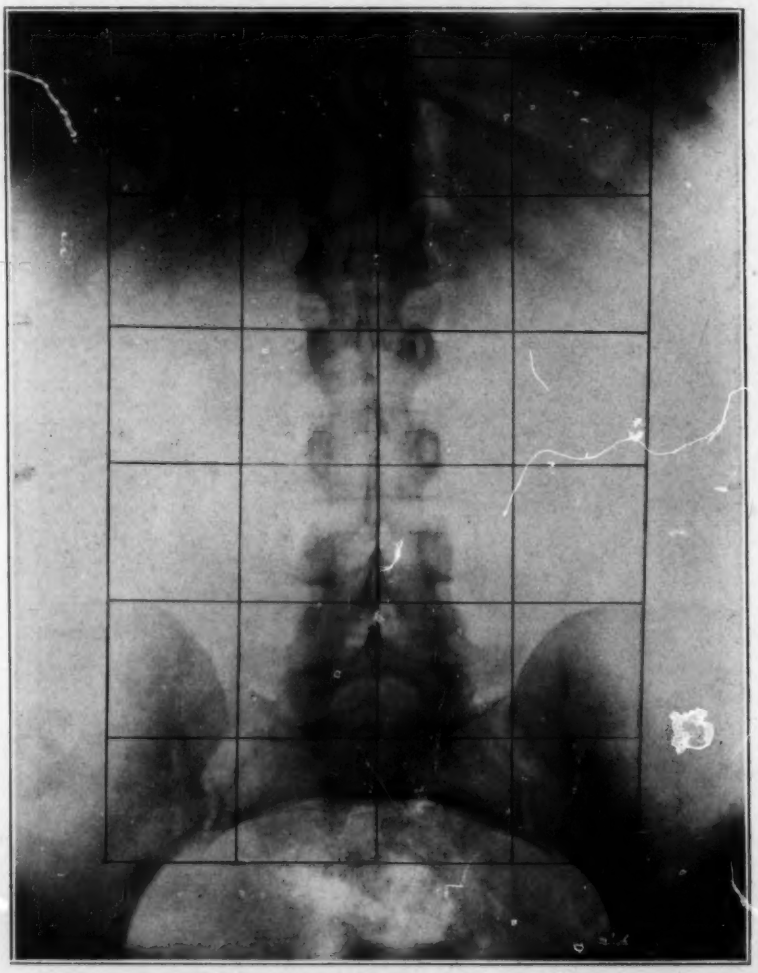

Fig 3.—Anteroposterior view of low back as seen through quadrille ruling; perpendicular line corresponding to axis of shadow of sacrum, and horizontal line crossing lower part of fourth lumbar vertebra at level of crests of ilia.

An anteroposterior film of the pelvis, including the lumbosacral region, shows many more clearly defined lines of definition than the lateral: the bodies of the vertebrae, their anterior, posterior, superior

1. Robinson, W. H.: Joint Range, J. Orthop. Surg. **3**:41 (Feb.) 1921.

and inferior surfaces, the transverse processes, the crests of the ilia, the sacrum with its foramina, the coccyx, the greater and lesser sigmoid notches and the rami. An important consideration in reading the anteroposterior view is that the patient must have been placed perfectly flat and the tube directly over the midline; otherwise, one side of the vertebrae will appear wider. It also is desirable that the central ray pass through a definite level, for instance the fourth lumbar vertebra.

In order to concentrate on detail in reading the anteroposterior film, a 2 inch quadrille ruling (Fig. 3) in India ink on a transparent sheet of celluloid, a washed off film, for instance, is a help. The sheet should be about 11 by 14 inches (27.9 by 35.4 cm.) and the ruling 8 by 12 inches (20.3 by 30.4 cm.) into 2 inch (5 cm.) squares. This will give a vertical center line and a horizontal center line. In use, the transparent ruled film is placed over the film to be read, the vertical center line corresponding to the axis of the sacrum or the horizontal center line corresponding to the tips of the iliac crests. Certain relationships will thus be made more striking than by a view of the film alone. For example: In normal cases, the vertical line corresponding to the axis of the sacrum will be found true also to the vertical axis of the fifth lumbar; the horizontal line from one iliac crest to the other will be found to divide horizontally the fourth lumbar vertebra in men and to be somewhat lower in women. The height of the transverse processes may be studied in relation to parts of the pelvis and spine, and, not least important, it becomes possible in reading both anteroposterior and lateral views of the same patient to form some conception of what relation exists between the two views.

We believe that, in the above, there is material for practical application in certain types of low back disability. A sudden change in the sacrovertebral angle may conceivably cause pain transmitted to the back of the leg from irritation of some of the nerves in the makeup of the sacral or lumbar plexus. We may ask if this irritation is due to pressure or to traction on the nerve? A glance at a cut of these plexuses will convince that a change in the angle at the base of the spine may put an undue amount of tension on a certain section of a nerve. For example: In a decrease of the angle (i. e., fewer degrees in the arc between the lines constituting it), there is conceivably, traction exerted on the sacral nerves, the strain acting at their point of union with the sacral plexus, or rather the point at which all the nerves of the plexus unite to form the great sciatic. Likewise, if the diminution of the angle is due to tilting backward of the fifth lumbar on the sacrum (usually accompanied by a similar tilting of the fourth lumbar on the fifth), there may be produced a tug on the branch of the fourth lumbar nerve that joins the fifth to

make the lumbosacral cord. In this case, the irritation would be produced at the point where the branch joins the fifth nerve or possibly at the sacral plexus union itself.

It should not be inferred from the foregoing that we believe that all low back trouble is due to variation in the degree of angulation at the base of the spine. Close attention to symptom complexes reveals many interesting variations that lead us to the belief that the site of irritation of a nerve may be from diverse causes and at different levels of its course.

5082 Jenkins Arcade.

EXPERIMENTAL HYDRONEPHROSIS

THE EFFECT OF CHANGES IN BLOOD PRESSURE AND IN BLOOD FLOW ON ITS RATE OF DEVELOPMENT, AND THE SIGNIFICANCE OF THE VENOUS COLLATERAL SYSTEM

III. Partial Obstruction of the Renal Vein Without and With Ligation of all Collateral Veins*

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The absence of any change in the ordinary rate of development of hydronephrosis when an increased blood flow through the kidney and a unilateral diuresis are produced by splanchnotomy has been experimentally demonstrated.[1] The present paper considers the effects on the rate of development of hydronephrosis of a diminished blood flow but increased intrarenal pressure and oliguria, brought about by partial obstruction of the renal vein. Partial constriction of the renal vein causes a capillary stasis and an increase in glomerular pressure which may rise in proportion to the degree of obstruction, "until with complete closure it may reach that of the renal artery" (Cushny). Despite this rise of pressure in the glomerulus, the amount of urine filtered through is diminished in indirect ratio to the amount of obstruction. The diminished blood flow has the predominant effect. But, with partial obstruction, will the rise in glomerular pressure, even though the amount of urine is diminished, so affect secretory pressure as to increase the rate of development of hydronephrosis? In other words, of what importance is secretory pressure as a cardinal factor in the production of hydronephrosis?

THE EFFECTS OF VENOUS OBSTRUCTION

Early investigators of urinary secretion studied the effects of venous constriction and the explanation of the results obtained have formed an

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*From the Department of Urology and Hooper Foundation of Medical Research of the University of California.

1. Hinman, Frank; and Hepler, A. B.: Experimental Hydronephrosis; the Effect of Changes of Blood Pressure and Blood Flow on the Rate of Development, I, Splanchnotomy, Arch. Surg. **11**:578 (Oct.) 1925.

important point of discussion in the controversy over theories of renal secretion.[2] Heidenhain considered this increase in glomerular pressure with a decrease in urinary output as evidence against Ludwig's filtration theory of glomerular function. Ludwig, however, explained this apparent discrepancy by arguing that the engorgement of the veins in the boundary zone of the kidney compressed the tubules, obliterated their lumina and thus prevented urine from reaching the pelvis. Later investigators have suggested that, in addition to this tubular obstruction, the decreased secretion of urine might be fully accounted for by such a distention of the glomerulus as to fill Bowman's capsule and thus reduce the filtering surface,[3] as well as by increasing osmotic resistance to filtration from the stagnation in the glomerular capillaries.

Much light has been thrown on this problem by the work of Richards and Plant.[4] By means of their perfusion pump, devised to maintain a constant circulation of hirudinized blood through the vessels of the kidney, they were able to make accurate observations of the effects of changes in the mechanical factor of renal secretion, the blood pressure. Keeping the blood flow constant, they used, among other methods, partial compression of the renal vein to increase the glomerular pressure; when the obstacles to filtration, such as compression of the tubules and stagnation in the glomerular capillaries, which exist in the intact animal, were removed by the irresistible pump, they noted invariably an increased output of urine whenever the vein was compressed. Undoubtedly, they also would have found, if tested, a corresponding variation in the renal secretory pressure. In the intact animal, it is impossible to dissociate renal blood pressure and blood flow, and, under these conditions when the vein is obstructed, investigators have almost invariably found an oliguria,[5] which would therefore seem to be due to the slowing of the blood flow. But even with a lowered blood flow and diminished urine output, the increased intraglomerular pressure might so affect filtration as to produce a rise in secretory pressure and thus have a definite effect on the rate of development of hydronephrosis.

Until the work of Rowntree, Fitz and Geraghty,[6] all studies of this problem had dealt with obstruction for short periods only. In an attempt to approximate the conditions seen in chronic passive congestion

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2. Paneth: Arch. f. d. ges. Physiol. **39**:515, 1886. Munck: Berl. klin. Wchnschr. **1**:333, 1864. Goll: Ztschr. f. rat. Med. **4**:78, 1854.

3. Sollman: Am. J. Physiol. **13**:241-303, 1905.

4. Richards, A. N., and Plant, O. H.: Am. J. Physiol. **59**:144-183 (Feb.) 1922.

5. Paneth, Munck, Goll (Footnote 2). De Souza: J. Physiol **26**:139, 1900. Ignatowski: Compt. rend. Soc. de biol. **58**:130, 1905.

6. Rowntree, L. G.; Fitz, R., and Geraghty, J. T.: The Effect of Experimental Chronic Passive Congestion on Renal Function, Arch. Int. Med. **11**:121 (Feb.) 1913.

of the kidney, these investigators placed sections of silk woven catheters about the vein, and studied the effect of this compression for periods of weeks and months. They concluded that prolonged slight constriction produced albumin, casts and blood without any significant change in the amount of urine, but that, as the constriction was increased, the

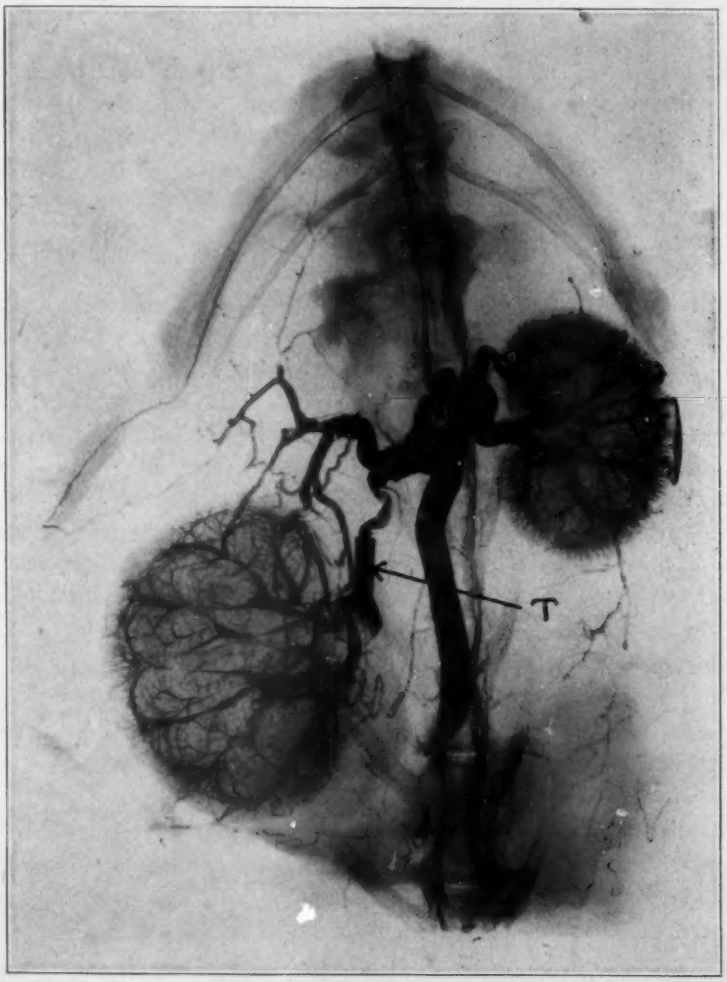

Fig. 1.—Venous barium sulphate injection of twenty-eight day hydronephrosis of left kidney of rabbit with partial compression of left renal vein; amount of venous compression obtained is demonstrated by a comparison of the lumen of tube (T) in place on the left renal vein and the size of the right vein; marked enlargement of the collaterals.

amount of urine diminished. In two instances, they noted a slight polyuria with partial compression. They lacked any control of the degree of venous obstruction applied.

We have, then, in partial venous obstruction, a procedure whereby we may increase intrarenal blood pressure in spite of oliguria and diminished blood flow through the kidney. What effect will this have on the rate of development of hydronephrosis?

The experimental data will be presented in two parts:

A. The effect of complete unilateral ureteral obstruction with partial obstruction of the renal vein.

B. The effect of complete unilateral ureteral obstruction with destruction of the perirenal venous collateral circulation and partial obstruction of the renal vein.

A. COMPLETE UNILATERAL URETERAL OBSTRUCTION WITH PARTIAL OBSTRUCTION OF THE RENAL VEIN

Technic.—Twelve rabbits were used. The left kidney was exposed through a lumbar incision, and the ureter divided between ligatures about 4 cm. from the pelvis. The renal vein was then carefully freed from the pedicle. A piece of fine rubber tubing, 1 cm. long with a lumen 3 mm. in diameter, was split, flattened out with forceps, placed under the vein, allowed to recoil about it and then secured with silk ties. The veins of a number of rabbits had previously been calibrated, and it was found that a tube of this size would produce approximately a 50 per cent. compression. We were able to confirm the degree of constriction by the barium sulphate injection and roentgenograms made at necropsy (Fig. 1) which insure the accurate control necessary in this type of experiment.

Findings.—We have previously determined,[1] for purpose of control, the measurements and pelvic capacities of the kidney for varying periods of obstruction in simple hydronephrosis, and have noted a characteristic increase which is proportional to the duration of the obstruction (Table 1).

Examination of numerous rabbits' kidneys that have been subjected to complete unilateral ureteral obstruction have confirmed this observation, and there has been noted but slight variation among the various specimens of the same period of obstruction.

Of the twelve rabbits subjected to ureteral ligation plus compression of the renal vein, two were killed seven days after operation; four at fourteen; two at twenty-one; two at twenty-eight, and one each at fifty-six and ninety days. The veins of the collateral circulation were enormously enlarged, the increase being especially noticeable in the suprarenal vein, the size of which, in some instances, equaled that of the renal vein (Fig. 1). A barium sulphate venous injection showed the degree of obstruction to the vein to be approximately the same in each instance (Fig. 1).

A comparison of this series, Table 2, with the control series, Table 1, shows an acceleration of the hydronephrosis in the early periods (up to twenty-one days), but, for longer periods of ureteral obstruction than twenty-one days, there is no increase over the usual rate. The acceleration in rate of development is most marked in the seven and twenty-one day periods, the latter showing a degree of hydronephrosis usually seen only after several months of ureteral obstruction (Fig. 2).

Discussion.—The interpretation of this acceleration in rate of dilatation in the early periods and no change in late periods raises points of

TABLE 1.—*Measurements of the Hydronephrotic Kidney in Rabbits After Total Ligation of the Left Ureter*

Duration, Days	Weight of Rabbit, Kg.	Measurements of Kidney			Pelvic Capacity, C.c.
		Length, Cm.	Depth, Cm.	Width, Cm.	
7	4.00	5.2 (0.1)*	3.5 (0.0)	3.3 (0.3)	4
14	2.72	4.3 (0.55)	3.0 (0.48)	2.8 (0.74)	8
21	4.00	6.0 (0.9)	4.4 (0.4)	3.8 (0.76)	10
28	3.02	5.0 (1.13)	3.4 (0.38)	3.5 (1.21)	13
56	3.00	5.2 (1.36)	3.7 (0.7)	3.5 (1.22)	25
90	2.89	5.5 (1.8)	3.8 (0.91)	3.6 (1.41)	33

* The figures in parenthesis indicate the actual increase in size when the measurements are proportioned to the animal's weight, using as a normal standard a rabbit that weighed 2.5 kg. and whose left kidney was 3.2 cm. long, 2.5 cm. deep and 1.9 cm. wide.

TABLE 2.—*Measurements of the Hydronephrotic Kidney After Total Ligation of Left Ureter and Partial Compression of the Renal Vein on the Same Side*

Duration, Days	Weight of Rabbit, Kg.	Measurements of Kidney			Pelvic Capacity, C.c.
		Length, Cm.	Depth, Cm.	Width, Cm.	
7	2.89	4.2 (0.51)*	3.3 (0.41)	2.8 (0.61)	5
7	2.7	4.2 (0.8)	3.1 (0.6)	2.9 (0.84)	9
14	3.16	4.8 (0.76)	3.5 (0.34)	3.0 (0.6)	7
14	2.5	3.8 (0.6)	2.8 (0.3)	2.5 (0.6)	5
14	3.0	4.84(1.0)	3.6 (0.6)	3.23(0.9)	9
14	2.5	4.1 (0.9)	3.0 (0.5)	2.8 (0.9)	8
21	3.0	5.8 (1.96)	3.75(0.75)	4.0 (1.79)	26
21	3.0	4.5 (1.42)	3.39(0.39)	3.2 (1.0)	18
28	2.89	4.84(1.15)	3.3 (0.41)	3.4 (1.31)	11
28	2.5	4.6 (1.14)	2.9 (0.4)	2.8 (0.9)	10
56	3.04	5.1 (1.21)	3.6 (0.56)	3.6 (1.29)	23
90	2.24	4.6 (1.88)	3.5 (0.91)	3.2 (1.5)	28

* The figures in parenthesis indicate the actual increase in size when the measurements are proportioned to the animal's weight, using as a normal standard a rabbit that weighed 2.5 kg. and whose left kidney was 3.2 cm. long, 2.5 cm. deep and 1.9 cm. wide.

interest. Is it to be accounted for by the individual variations that occasionally occur in hydronephrosis, since it occurs in the early periods only, or can it be explained as due primarily to the effects of the venous obstruction, in spite of the absence of change in late periods? Although variations in the rate of development of simple hydronephrosis are occasionally seen, they are very rare in the rabbit and even then of a minor degree. One is able to estimate with a reasonable degree of certainty the duration of the ureteral obstruction by the degree of dilatation and hydronephrotic atrophy. The initial acceleration, in this series, is

so constant in the early period specimens and so marked, being from two to three times that usually seen for the same period of simple obstruction (Fig. 3), that it can be regarded as due to the partial constriction of the renal vein. However, if we attribute this accelerated rate of development to the effects of venous compression, how explain the absence of any change in rate after twenty-one days? The answer is found in the behavior of the venous collateral system.

Fig. 2.—Lower: twenty-one day hydronephrosis with partial compression of the renal vein, showing a greater degree of dilatation than simple hydronephrosis (upper) for the same period.

Enlargement of the venous collateral circulation of the kidney in simple hydronephrosis has been noted by various observers, and has occurred in all of our series. To compensate for the venous stasis that

follows intrarenal compression of the venous radicles incidental to urinary back pressure from simple ureteral obstruction, there is enlargement of the numerous collateral veins. In fact, these accessory veins are capable, in part or in whole, of assuming the function of the renal vein. When the ordinary stasis of urinary obstruction is added to by partial compression of the vein, the compensatory action of the collaterals becomes of great importance (Fig. 4). Collateral enlargement is not compensatory apparently until after twenty-one days. Therefore, the rate of development of hydronephrosis is accelerated by partial venous obstruction up to twenty-one days, but, for longer periods, the compensatory development of the collaterals nullifies the hastening effect of the compression, and hydronephrosis progresses at its usual rate. The question arises: Is this initial acceleration in rate of development due to

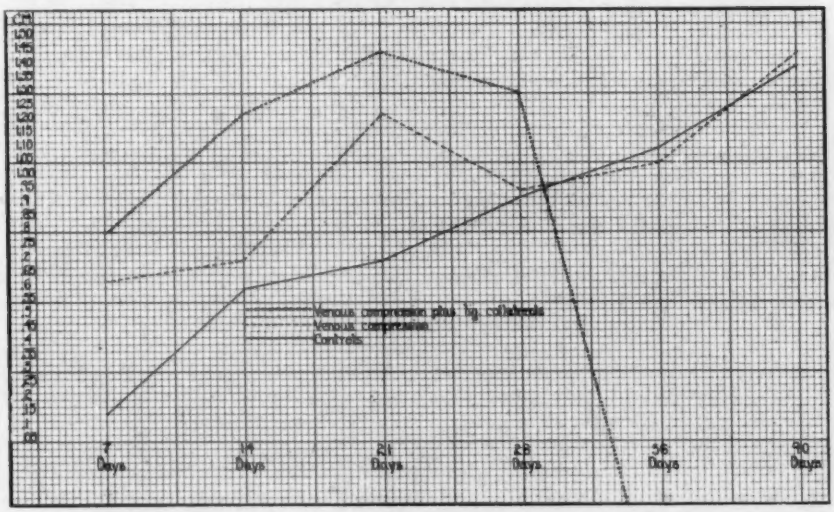

Fig. 3.—Variation in rate of development of hydronephrosis with destruction of venous collaterals and partial compression of renal vein illustrating the actual increase in size of the hydronephrotic kidney for the various periods of obstruction under the following conditions: (1) simple ureteral obstruction; (2) ureteral obstruction plus partial venous compression, and (3) ureteral obstruction, partial venous compression and destruction of the venous collaterals. The figures are compiled from measurements given in Tables 1, 2 and 3.

the increase in the degree of urinary back pressure that follows venous compression but is later lost by the compensatory activity of collateral veins, or is it due rather to an increase in the degree of tissue anemia from venous stasis which hastens dilatation just as partial compression of the artery has been found to do, this stasis being likewise later removed by the compensatory collaterals? In either case, would not the complete ligature of all collateral veins at the time of ureteral ligature

and partial venous compression be expected to give continued acceleration in rate of dilatation beyond the twenty-one day period? This, however, is found not to occur.

B. COMPLETE UNILATERAL URETERAL OBSTRUCTION, DESTRUCTION OF THE PERIRENAL VENOUS COLLATERAL CIRCULATION AND PARTIAL OBSTRUCTION OF THE RENAL VEIN

Technic.—The left kidney in each of seven rabbits was exposed, and the ureter divided between ligatures 4 cm. from the pelvis. The veins of the collateral circulation (the suprarenal, spermatic or ovarian, lumbar, subdiaphragmatic and all other branches seen in the kidney region but not identified) were ligated and divided or simply ligated when inaccessibility made division difficult, as near to the vena cava as

TABLE 3.—*Complete Unilateral Uretheral Obstruction, Partial Compression of Renal Vein and Ligation of Venous Collaterals*

Duration, Days	Weight of Rabbit, Kg.	Measurements of Kidney			Pelvic Capacity, C.c.
		Length, Cm.	Depth, Cm.	Width, Cm.	
7	2.7	4.3 (0.84)*	3.4 (0.7)	2.9 (0.84)	..
14	2.8	4.8 (1.72)	3.6 (0.8)	3.3 (1.18)	..
21	3.0	4.3 (1.46)	4.2 (1.2)	4.0 (1.82)	..
28	2.5	4.6 (1.4)	3.8 (1.3)	3.1 (1.2)	..
36	3.6	3.5	2.5	1.4	2
Hydronephrotic dilatation but marked general shrinkage of kidney †					
43	3.1	2.3	1.8	1.1	1
Hydronephrotic dilatation but marked general shrinkage of kidney					
56	2.2	2.5	1.5	1.3	0
No hydronephrotic dilatation; primary atrophy					

* The figures in parenthesis indicate the actual increase in size when the measurements are proportioned to the animal's weight, using as a normal standard a rabbit that weighed 2.5 kg. and whose left kidney was 3.2 cm. long, 2.5 cm. deep and 1.9 cm. wide.
† Illustrated in Figures 7 and 8.

possible. The renal vein was then partially obstructed in the manner described above. Thoroughness in ligature of veins near the vena cava is important. In several control animals in which the collaterals were ligated without obstruction to the ureter, barium sulphate injections subsequently revealed small branches coming from these main collateral vessels near their entrance into the vena cava, that might, on demand, enlarge to a considerable size.

Findings.—Animals were killed seven, fourteen, twenty-one, twenty-eight, thirty-six, forty-three and fifty-six days following operation. Stereoscopic roentgenograms of barium sulphate venous injections were taken at the end of each experiment to determine the thoroughness of the obliteration of the collaterals. Small lumbar or subdiaphragmatic branches, not perceptible at operation, may undergo marked enlargement under the demand of the venous stasis of ureteral obstruction. In Figure 5, which represents the roentgenogram of the twenty-one day specimen, it will be noted that the obliteration of the collaterals has been

successful except for a small branch from the last thoracic vein and a small lumbar branch from the vena cava near its bifurcation. These branches have not enlarged to a degree to influence the experimental result. A comparison of this illustration with Figure 4 is instructive.

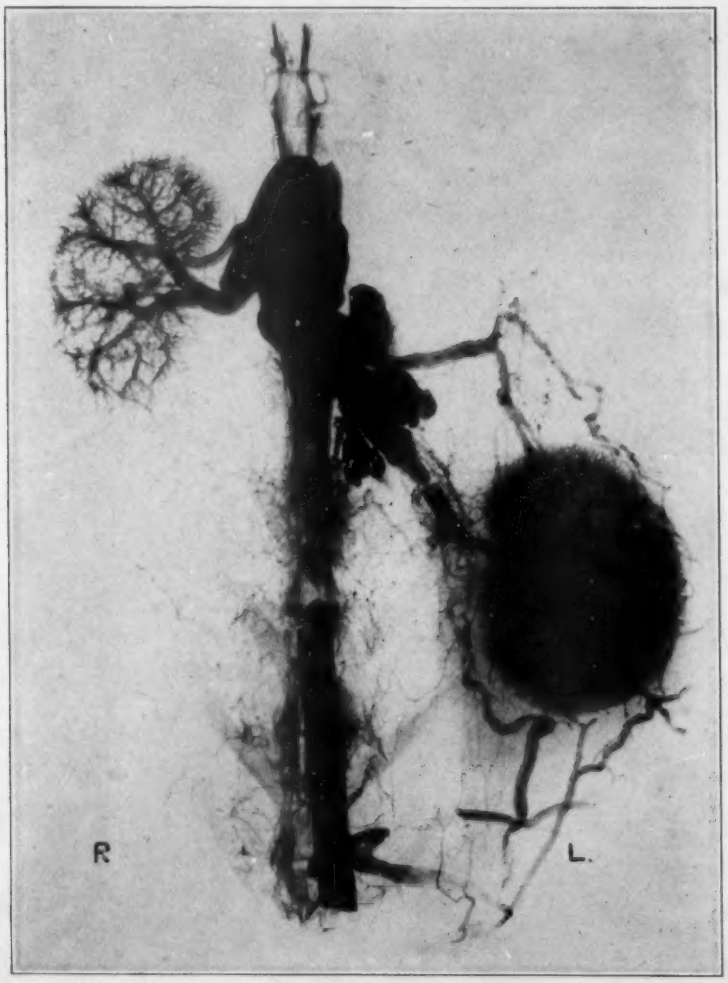

Fig. 4.—Venous barium sulphate injection of a hydronephrotic kidney with partial compression of the renal vein; marked enlargement of the venous collateral circulation, which is evidently accelerated by the partial venous obstruction.

The results that have followed partial compression of the renal vein with complete ureteral ligation and destruction of collaterals are of interest in comparison to the findings (in Group A) of a hastening effect of partial venous compression with ureteral ligation on the

Fig. 5.—Venous barium sulphate injection of a twenty-one day hydronephrosis with partial obstruction of the renal vein and ligation and division of the venous collateral circulation. The destruction of the latter has been successful, except for a small branch from the last thoracic vein and a lumbar branch from the vena cava near its bifurcation. These have enlarged but evidently not to a degree to influence the experimental result. Comparison should be made with Figure 3.

development of hydronephrosis, but particularly in demonstrating the rôle of the venous collaterals in hydronephrosis.

The measurements of the seven kidneys of Group B are given in Table 3.

The seven, fourteen and twenty-one day specimens show a greater increase in the degree of hydronephrosis than the same periods with venous compression without ligation of the collaterals (Table 2) over the ordinary degree of hydronephrosis of the controls (Table 1) (Figs. 3 and 6). The amount of dilatation in the twenty-one day specimen even equals that usually seen after three months of simple ureteral obstruction. There is also a great increase for the twenty-eight day period, but this is relatively less than that of the fourteen and twenty-one day periods.

The findings in the later periods, those beyond twenty-eight days, are especially interesting in their bearing on the significance of a compensatory collateral circulation. The thirty-six day specimen shows marked decrease in size, a pronounced general shrinkage of the kidney (Fig. 7), as compared to a similar period of ureteral block of either the control or simple venous compression series, and this condition is present to a more marked degree in the forty-three day specimen (Fig. 8), which indicates that secondary atrophy occurs in the later periods of ureteral block with venous compression when the collaterals are obliterated (Fig. 8). The fifty-six day specimen, in which there is an abscess of the pyramid, shows an atrophy that appears to be primary, in that it has not been preceded by a hydronephrotic dilatation, and this and other findings [7] confirm our belief in the importance of infection in the production of primary atrophy in the presence of complete ureteral obstruction.

Comment.—Tuffier and Lejars [8] have studied the venous collateral circulation of the kidney, and find that the fatty capsule contains a rich venous plexus. These veins are connected, on the one hand, with the renal circulation: by emptying into (a) the renal vein and its branches; (b) connections with the stellate veins of the kidney, and (c) perforating capsular branches that pierce the cortex, and, on the other, with the general circulation: through anastomoses with the (a) suprarenal and subdiaphragmatic veins; (b) spermatic or ovarian, (c) subcutaneous plexus of the lumbar region, and (d) the plexus that surrounds the last intercostal and the iliohypogastric and ilio-inguinal nerves. This collateral circulation is capable of taking over the function of the renal vein, as demonstrated by the fact that, after gradual complete occlusion

7. Discussed in another paper of this series: The Effect of Ligature of One Branch of the Renal Artery on the Development of Hydronephrosis.

8. Tuffier and Lejars: Arch. d. physiol. norm. et path. 1891.

of the vein, the kidney resumes a normal function and can sustain life when the opposite kidney is removed, if sufficient time is allowed to elapse to permit the compensatory development of the collaterals.[9]

Lindemann [10] considers that this anastomosis in the fatty capsule plays an important part in the mechanism of hydronephrosis, for the reason that, in six dogs in which he ligated the ureter, hydronephrosis developed only in three and primary atrophy in the others, in which he noted an absence of enlargement of the collaterals. He therefore concluded that when the ureter is blocked, urinary back pressure not only obstructs the vessels at the hilum but also compresses the venous capillaries. When individual conditions permit the compensatory develop-

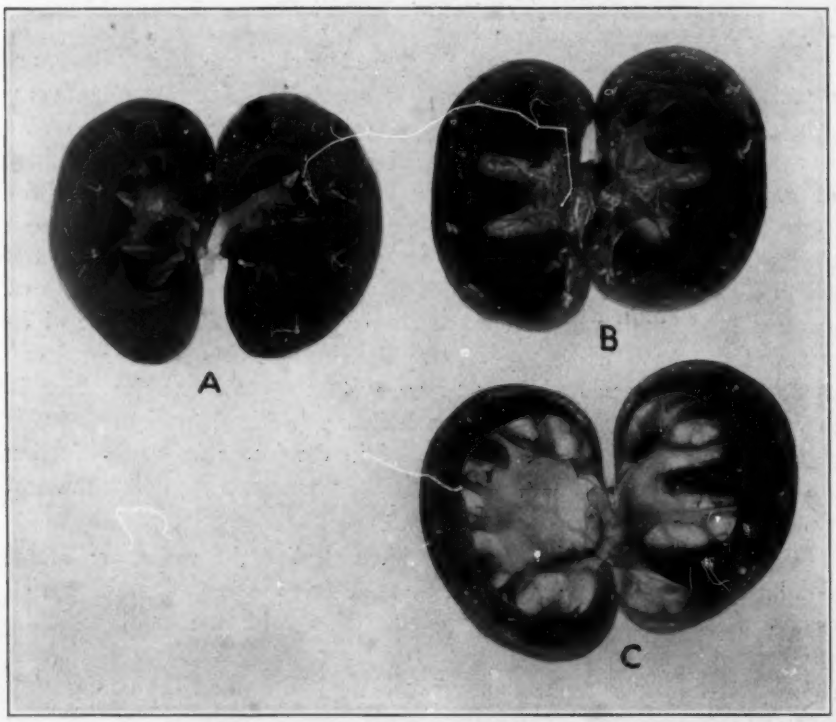

Fig. 6.—Acceleration in the rate of development of hydronephrosis produced by partial compression of the renal vein and destruction of the perirenal venous collaterals; *a*, control with complete ureteral obstruction after twenty-one days; *b*, complete ureteral obstruction and partial constriction of the renal vein after twenty-one days, and *c*, complete ureteral obstruction, partial venous constriction, and destruction of the perirenal venous collaterals after twenty-one days.

9. Rowntree, Fitz and Geraghty (Footnote 6). Alessandri: Ann. d. mal. d. org. genito-urin. **18**:473-506, 1900.

10. Lindemann: Centralbl. f. allg. Path. u. path. Anat. **6**, 1895.

ment of the collateral circulation, hydronephrosis will develop, but, when there is no compensatory enlargement of the collaterals, primary atrophy will occur.

Barney [11] seemingly confirmed Lindemann's theory by results following destruction of the collateral circulation simultaneously with ureteral ligation in two dogs, both killed fifty days after operation (severe infection nullified the results in two experiments), in one of which a

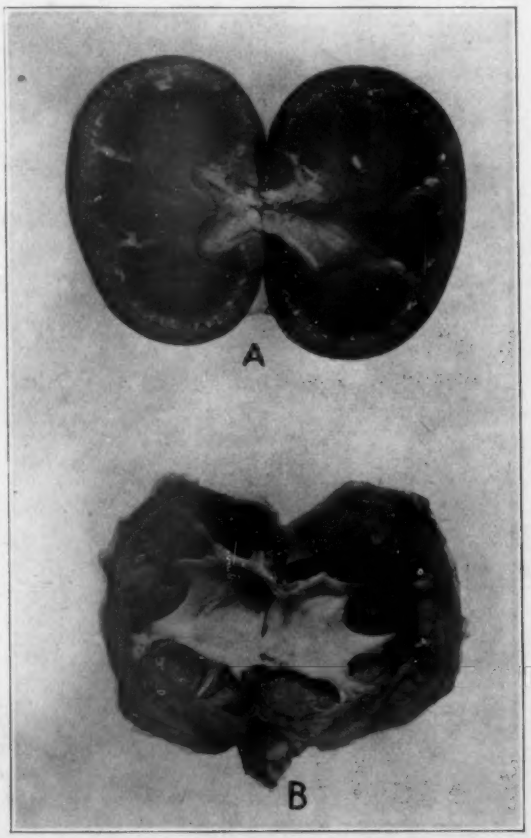

Fig. 7.—Secondary atrophy following an early hydronephrosis, illustrating the effect (in the later periods of hydronephrosis) of obliteration of the venous collaterals: *a,* normal right kidney; *b,* left kidney after thirty-four days of complete ureteral obstruction, partial compression of the renal vein and destruction of collaterals; diminution in size should be noted and comparison made with Figure 8.

primary atrophy occurred; in the other, although there was not a complete cessation of function, he regarded the condition as a beginning atrophy.

11. Barney: Ann. Surg. **65**:597, 1916.

Scott [12] denies any connection between the rate of development of hydronephrosis and the compensatory action of collateral venous circulation. In two instances, he completely destroyed the collaterals and, to insure against any reestablishment, surrounded the kidney with silk and gutta percha. He killed his animals at seven and twenty-two day periods, and noted hydronephrosis in each instance, although the twenty-two day specimen showed a slight shrinkage which he interpreted as a possible beginning atrophy. Conciliation of these apparently variable findings is possible when the changes of the different periods of ureteral

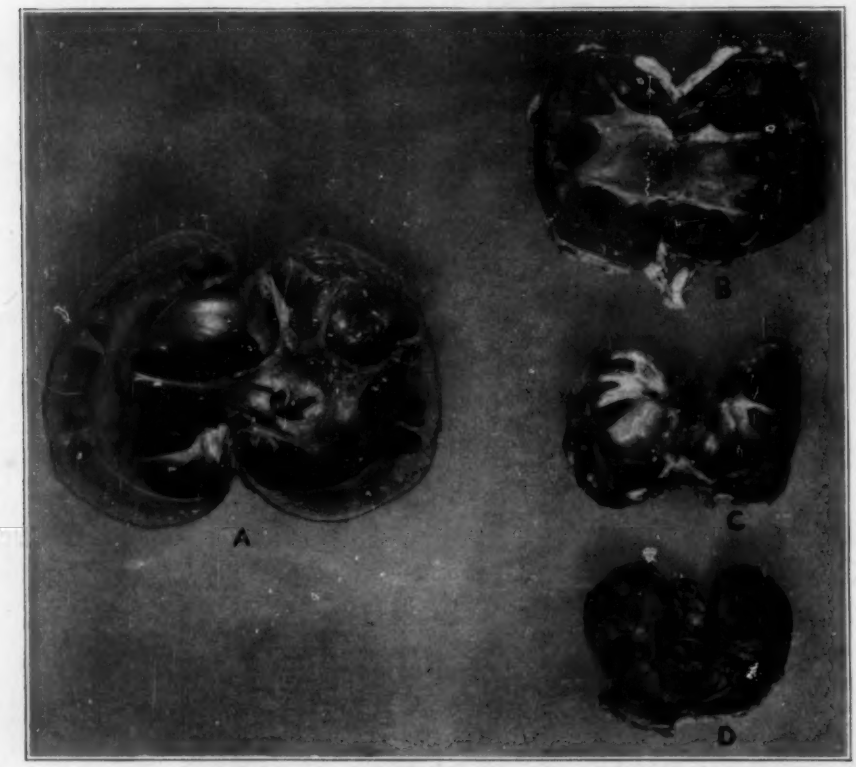

Fig. 8.—Gross specimen illustrating the effect of obliteration of the venous collateral circulation on the development of hydronephrosis: *A*, kidney on the left, is a fifty-six day hydronephrosis from simple ureteral obstruction used for a comparison with the group on the right; *B*, thirty-six day hydronephrosis with obliteration of collateral; *C*, forty-three day hydronephrosis with obliteration of collateral; *D*, fifty-six day ureteral obstruction with obliteration of collateral showing primary atrophy. *B* and *C* represent a secondary atrophy or shrinkage following an early hydronephrosis, and must not be confused with primary atrophy.

12. Scott: Surg., Gynec. & Obst. **15**:296, 1912.

obstruction are considered. The duration of ureteral obstruction in Scott's animals was for early periods only; in Barney's, both fifty days. In our series, animals killed at approximately these same periods gave like results, so that their individual observations are not at variance with one another or our own but are incomplete.

In a study of the effect of destruction of collaterals on the rate of development of hydronephrosis in rabbits by A. E. Belt in our laboratory (unpublished), no difference over a parallel control series was noted, but the series was not large enough to warrant definite conclusions. It is probable that a large number of secondary atrophies will occur in kidneys with collateral veins ligated than in simple hydronephrosis, but only for relatively long periods of obstruction. In the foregoing two experimental conditions, the compensatory action of the collaterals is well illustrated. In animals with simple compression of the renal vein, the hastening effect on hydronephrotic dilatation of venous stasis is lost with the establishment of collateral compensation. In animals with venous compression and ligature of all collaterals, venous stasis is more increased, and so is the acceleration in rate of dilatation, but in this case, the increased rate of hydronephrotic atrophy brings on its own destruction by producing such a rapid and marked stasis as to lead to secondary atrophy.

These findings together indicate that the acceleration of hydronephrosis with partial compression of the renal vein is due principally to the increased urinary back pressure of its early periods of obstructions.

CONCLUSIONS

1. Prolonged partial obstruction of the renal vein produces not only a diminished blood flow through the kidney and an oliguria, but also an increased intrarenal pressure, and, if the degree of obstruction is not too great, an increased secretory pressure.

2. When this procedure is combined with complete ureteral obstruction on the same side, the usual course of development of hydronephrosis is accelerated up to twenty-one days, after which the rate of development follows that ordinarily seen in the longer periods in simple hydronephrosis. The venous stasis of the early periods is nullified in the later by the compensatory action of the perirenal collaterals.

3. When the action of the venous collateral system is destroyed by complete ligation, and then partial constriction of the vein is combined with complete ureteral obstruction, there is an increase of the acceleration in the rate of development for the early periods of hydronephrosis over that even of simple venous constriction. Beyond twenty-eight

days, however, marked shrinkage of the kidney, a secondary atrophy, occurs, owing to the marked venous occlusion as a result of failure of a collateral system.

4. The action of the venous collateral system, therefore, is compensatory, and its development or nondevelopment is not an essential factor in simple hydronephrosis. Its failure may be an important one in the rare instances of late secondary atrophy of simple hydronephrosis, as it is the prime factor in the secondary atrophy with venous constriction.

5. The initial acceleration in the rate of development of hydronephrosis that occurs with venous constriction is primarily the result of increased secretory pressure, and only secondarily the result of the nutritional disturbance.

THE OSTEOGENETIC FUNCTION OF THE PERIOSTEUM *

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Several years ago, I devoted considerable time to the study of serial sections of the extremities of human fetuses of different ages, for the purpose of following the development of the periosteum and the different stages in the differentiation of the skeleton. As time goes by, the question as to whether or not the periosteum possesses an osteogenetic function seems no nearer solution than it did centuries ago. This is in all probability due to the fact that observers obtain the wrong point of view from the study of adult tissues.

Recently, Haas has given a résumé [1] of the work that has been done to prove or disprove that the periosteum has an osteogenetic function. From a survey of the facts already put forth in the literature, it becomes very evident that the embryonic history of the periosteum has been quite neglected in the current discussions, although fully considered in the textbooks on human embryology.[2] In 1867, Ollier drew attention to the differences in osteogenesis of different animals and of the different bones in the same animal.

The skeleton is developed from mesoderm, and a consideration of the development of bone, from the time of the first appearance of that blastodermic layer, is not germane to the present thesis. It is necessary, however, to recall the fact that from the mesenchyma (blastemal tissue) a membranous skeleton is developed, from which bone is differentiated, or cartilage, which is later replaced by bone. The first stage of the skeleton is the axial notochord of the embryo. In the amphioxus, the lowest of all vertebrates, this becomes the permanent skeleton of that animal. In the higher vertebrates, the next stage in the order of skeletal development is the membranous, then the cartilaginous and, finally, the osseous. We therefore see that each bone of the skeleton has its own embryonic history which is to be traced through three periods of development, not including the embryonic notochordal stage. These may be stated as follows: (1) membranous, or blastemal; (2) chondrogenous, and (3) osteogenous.

For the purpose of the present discussion, and for the sake of brevity, only certain long bones will be considered, as they present the

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* From the Laboratory of Surgical Pathology, Stanford University School of Medicine.

1. Haas, S. L.: The Importance of the Periosteum and Endosteum in the Repair of Transplanted Bone, Arch. Surg. 8:535 (March) 1924.

2. Keibel and Mall: Manual of Human Embryology, 1910.

essential data; and, for the purpose of clearness and contrast, an occasional incidental reference to the development of a short bone or an epiphysis will be made.

No sooner does the membranous anlage of a long bone differentiate in the blastemal tissue of a limb bud than a progressive cartilaginous change appears and continues until the membranous anlage is replaced by cartilage. Certain bones, known as membrane bones (intramembranous ossification), never pass through a cartilaginous stage, but ossify directly from membrane, either in part or as a whole. These bones are mainly confined to the cranium and face. The mesenchymal tissue enveloping the cartilaginous skeletal anlage differentiates into a fibrous membrane, the *perichondrium*.

In a human fetus at the sixtieth day of development, the perichondrium is cellular about the chondral diaphysis of a digital phalanx, which is beginning to show enlargement of the cartilage cells at the site of the primary center of ossification. Figure 3 shows these changes better than words can describe them. The cartilaginous matrix of the phalanx, while clear, shows a slightly granular condition, due to the beginning deposition of calcium salts. At this period there is no evidence of blood vessels within the cartilaginous diaphysis, and no vascular tufts are found entering from the perichondrium.

In the femur at the sixtieth day of development, taken from the same fetus from which Figure 3 was taken, the diaphysial cartilaginous matrix is well calcified and stains deeply with hematoxylon. Calcification likewise occurs in the tibia and fibula, humerus, radius and ulna. At the middle two thirds of the femoral diaphysis (Fig. 4), the cartilage is constricted, and the constriction corresponds to the area of calcification. Beneath the enveloping perichondrium of this area, a thin shell of bone has been deposited, and this cylindrically envelops and constricts the cartilaginous diaphysis which had already become fixed from calcification.

It is a fact that the first bone is subperichondral. It is likewise obvious that the perichondrium has changed its function and must from that time on be known as periosteum and the bone as subperiosteal bone. At this period, serial sagittal sections of the femur show no evidence of blood vessels within the cartilaginous diaphysis, nor is there any evidence of vascular periosteal buds entering the cartilage. It is therefore a fact that enlargement of the cartilage cells and calcification of the matrix take place before blood vessels or vascular tufts enter the cartilaginous diaphysis at that stage; also, that bone appears before the advent of marrow.

Later, vascular buds from the periosteum penetrate the subperiosteal cylinder of bone, and absorption of the calcified cartilage begins. This absorption results in the development of the primary marrow spaces

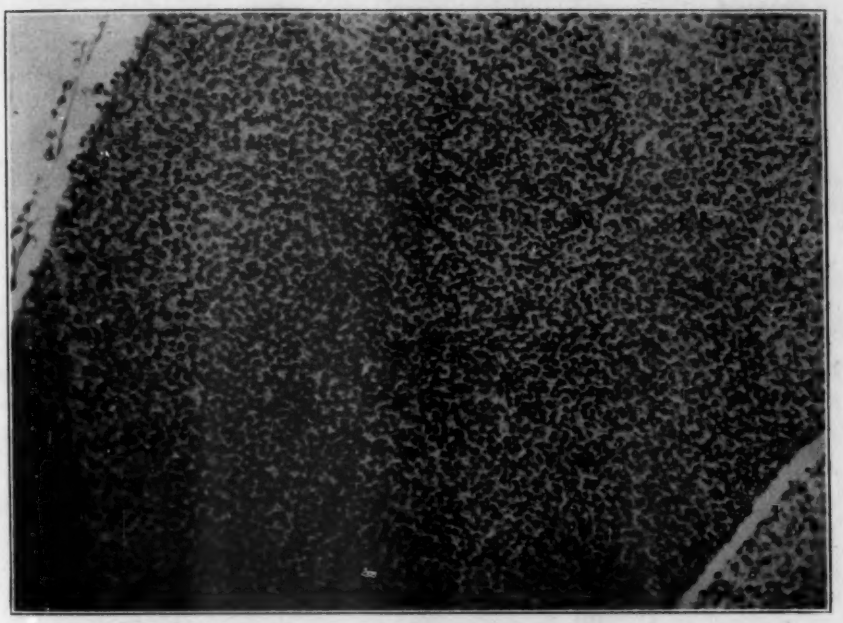

Fig. 1.—Sagittal section of anterior limb bud of pig embryo, showing condensed state of mesenchymal tissue preceding blastemal anlage of limb skeleton.

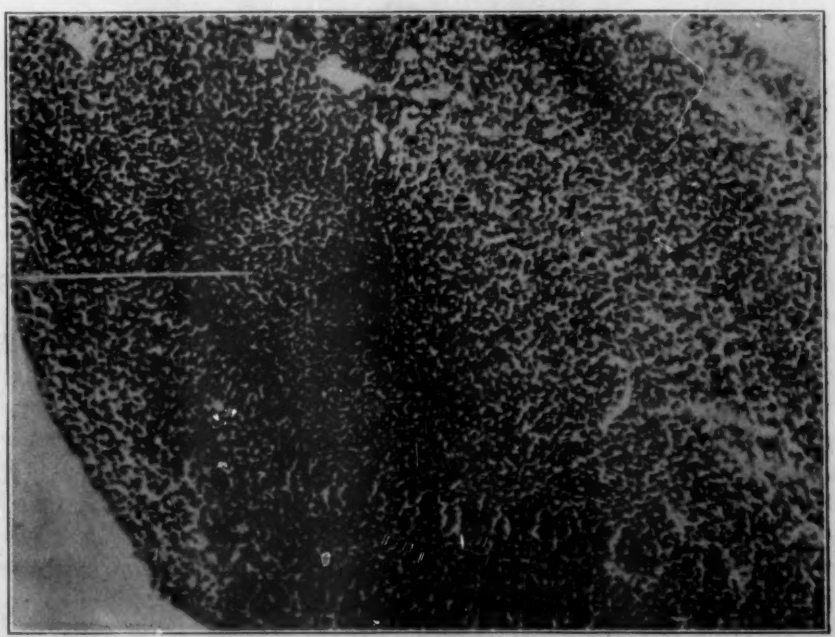

Fig. 2.—Portion of sagittal section of anterior limb bud of a pig embryo 9 mm. in length; part of condensed mesenchyma (scleroblastemal tissue) preceding the differentiation of the membranous skeleton (blastemal stage) at *A;* density of tissue; cells are not as round as those shown in Figure 1.

and the beginning deposition of endochondral bone. Figure 5, made from a sagittal section of a finger of a stillborn human fetus at full term, shows a portion of the distal extremity of the first phalanx. Endochondral bone formation is well under way. Vascular buds from the periosteum have penetrated the cartilage, which has been in part absorbed, and the resulting spaces have become primary marrow spaces.

Szymonowicz, in his "Textbook of Histology," MacCallum's translation, Figure 193, gives two thirds of a second phalanx of a finger of a 3½ months' human fetus in longitudinal section. It shows a vascular periosteal bud perforating the subperiosteal bone and just beginning to enter the cartilage. Figure 195 of the same textbook gives a diaphysis of the second phalanx of a 4 months' human fetus. This shows a more advanced absorption of the cartilage and a large primary marrow space. My own observations agree with these figures.

For the purpose of contrast and comparison, it is worth while to mention, at the present time, that in the epiphyses of long bones vascular buds grow in from the perichondrium before any changes take place in the hyaline cartilage. These buds penetrate deeply and inaugurate the changes that result in the progressive ossification of the epiphysis (Figs. 6, 7 and 8). The ossification of an epiphysis proceeds from within outward. Endochondral ossification of the diaphysis progresses toward the epiphyseal plate and is active in the metaphysis throughout the growing period. In the epiphyses, ossification progresses toward the epiphyseal plate; the latter, through cell proliferation, maintains a definite thickness throughout the growing period and gradually wanes as full growth is attained. The body of an epiphysis remains cartilaginous peripherally, gradually undergoing ossification from the more central parts, meeting the subperiosteal bone as it extends extremityward as full growth is attained.

In the phalanges and other long bones of moderate size, the cartilage at the point of entrance of a vascular bud may undergo considerable absorption, a large primary marrow space resulting, before endochondral ossification begins. The earliest or primary marrow is very vascular and contains an embryonic syncytium not highly differentiated. "Osteoblasts, osteoclasts and embryonic connective tissue, however, appear at an early stage; fat and marrow cells at a later period." [2]

About the primary marrow spaces, spongy endochondral bone soon appears. Portions of the calcified matrix are more or less enveloped by this early osteoid tissue; this matrix, as a rule, contains no cartilage cells. The advancing vascular tufts of the primary marrow open up the cartilage cell cavities or lacunae, and the intercolumnar matrix is partly absorbed and partly surrounded by the new bone. The bone first deposited is later absorbed during development and readjustment of the larger central marrow spaces.

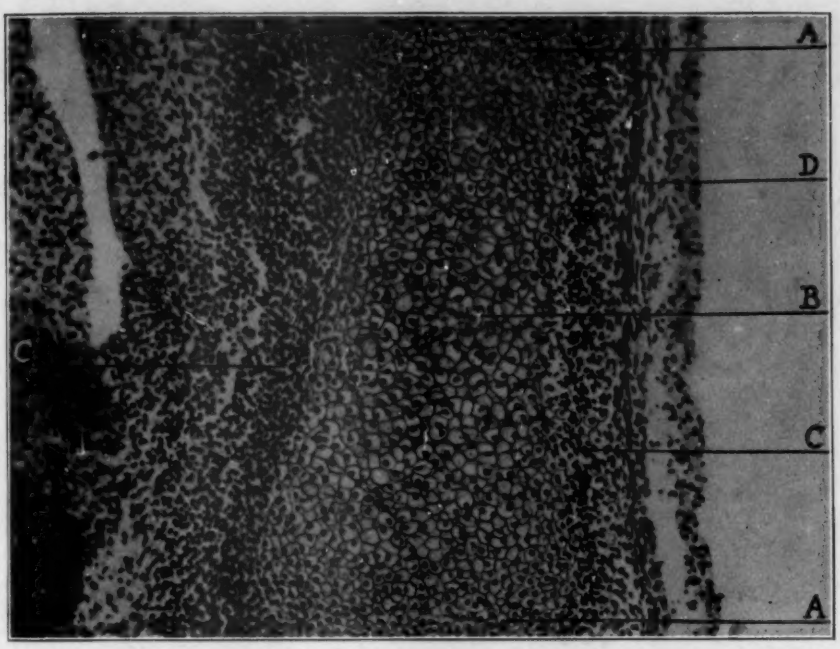

Fig. 3.—Sagittal section of basal phalanx of thumb of human fetus at about the sixtieth day of development: vertex breech measurement, 31.5 mm.; *A*, hyaline cartilage; *B*, enlarged cartilage cells; *C*, cellular perichondrium and potential osteogenetic tissue; *D*, developing extensor tendon; hematoxylon and eosin stain.

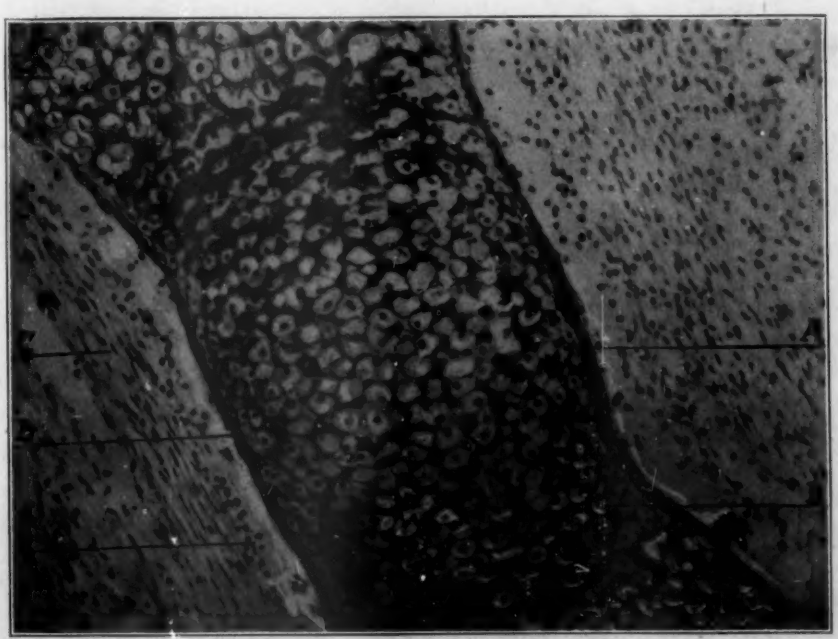

Fig. 4.—Longitudinal section of femur of same fetus as that in Figure 3: *A*, calcified cartilaginous matrix; *B*, subperichondrial layer of bone cylindrically enveloping the cartilaginous diaphysis; *C*, fibrous layer of the perichondrium (periosteum); *D*, cellular or osteogenetic tissue; *E*, enlarged cartilage cells, matrix not yet calcified; hematoxylon and eosin stain.

It is to be noted that certain changes in the cartilage precede the advance of the vascular medullary tufts. As the osteogenetic tissue spreads, the changes in the surrounding cartilage are similar to those which took place at the primary center of ossification. It can be seen in Figure 9 that as long as the process of ossification continues, the cartilage farthest removed from the center of ossification shows the least modification from the primary hyaline cartilage; while as one passes toward the center, successive changes of cell multiplication, cell expansion and calcification of the matrix are observed.

Therefore, Figures 5 and 9 show how this multiplication of cartilage cells gives rise to groups which become arranged in long columns parallel to the long axis of the bone, and that the boundary line between the zone of ossification and that of the highly modified cartilage is fairly sharp. In all specimens, the capillary loops extend close to the limit of advancing ossification; the extremities of the loops are more or less dilated.

Figure 10 shows the porous condition of the new subperiosteal bone of the femoral diaphysis described above. The periosteum is thick. The cellular layer (osteogenetic) is more cellular in some places than others. The surface of the subperiosteal bone is irregular here and there; at such places, giant cells (osteoclasts) are seen. The osseous trabeculae show no evidence of lamellation; the haversian spaces or canals open more or less widely beneath the periosteum. Each canal has a capillary running along its central axis, and these capillaries are supported by a delicate mesenchymal connective tissue syncytium; vascular spaces also are numerous. In this tissue, few marrow cells are observed. Cells (osteoblasts) are distributed in a single layer on the surface of the osseous trabeculae; others are more or less removed into the connective tissue. Bone of endochondral origin is not shown in the photomicrograph.

A study of the cellular layer of the periosteum shows many cells that can be recognized as osteoblasts. Those in relation with the surface of the subperiosteal bone (Fig. 11) are sparsely placed, and many are becoming buried or surrounded by the osseous deposits, and finally occupy lacunae. The latter cells are then termed bone cells.

Figure 5 shows a more advanced stage of subperiosteal ossification. It also shows endochondral ossification more advanced and in contrast with the contiguous subperiosteal bone. The latter is quite thick and extends in advance of the endochondral ossification, over the cartilaginous metaphysis, where it quickly thins out and ends. In the cellular layer of the periosteum there is a marked proliferation of the osteogenetic elements. Osteoblasts are present, and a constructive process is obvious; at other points, osteoclasts are seen, and rarefaction

Fig. 5.—Sagittal section of finger of stillborn human fetus at full term, showing portion of distal extremity of first phalanx: *A*, periosteum; *B*, subperiosteal bone; *C*, osteoclasts in Howship's lacunae; *D*, primitive marrow; *E*, epiphyseal cartilage; *F*, calcified cartilaginous matrix surrounded by newly formed endochondral bone; *G*, subperiosteal bone advancing toward the epiphyseal line; hematoxylon and eosin stain.

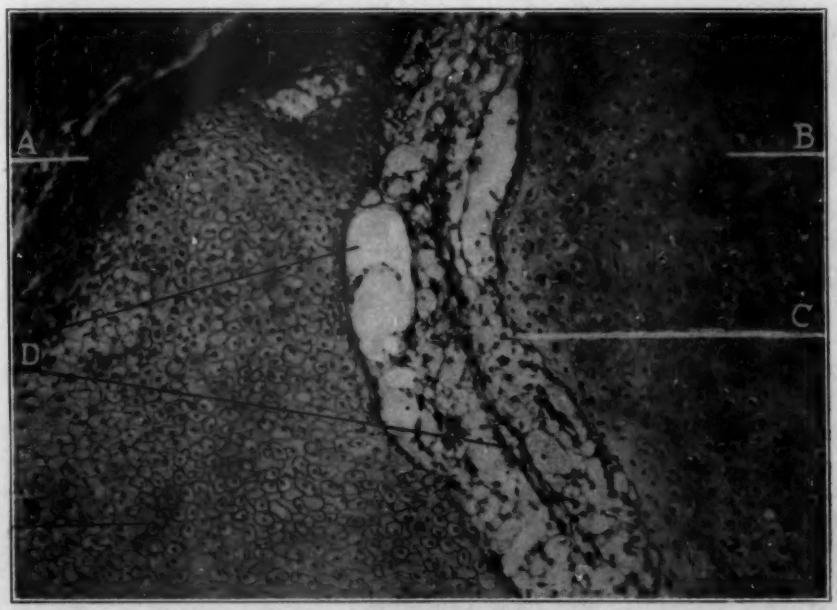

Fig. 6.—Sagittal section of foot of human fetus after about 121.5 days development: vertex breech measurement, 13.5 cm., showing a portion of distal cartilaginous epiphysis of tibia; *A*, perichondrium; *B*, hyaline cartilage; *C*, vascular perichondrial bud penetrating to depths of epiphysis; *D*, vascular spaces and central capillary within the bud. From the collection of the Laboratory of Surgical Pathology.

of the bone is taking place. At a point not shown in the photomicrograph, a vascular periosteal bud is present and has entered the diaphysis as shown in the textbook of histology referred to (Szymonowicz, Fig. 195).

The photomicrographs and the foregoing references demonstrate beyond all doubt the facts given in the text.

COMMENT

From the foregoing review of facts regarding the early development of bone, it can readily be perceived that the first bone in the extremities of a human fetus is deposited by the perichondrium (periosteum), in the form of a cylindrical envelopment of the cartilaginous diaphysis of the long bones about the region of the primary center of ossification. The cartilaginous diaphysis of a long bone, in a fetus at the sixtieth day of development, is devoid of any blood vessels, and all evidence of the presence of marrow is likewise negative. Let it be known that the time limit may vary in different animals and in bones of the same animal.

The periosteum, at this period, consists of two layers, an outer or fibrous and an inner and very cellular layer. Under high power, this cellular layer, at the sixtieth day and even earlier, contains cells that can be recognized as osteoblasts; they can quite surely be recognized as the forerunners of the cells of the newly formed bone, as they can be seen more or less buried on the surface of the subperiosteal bone (Fig. 11). In other words, they become the bone cells occupying the lacunae in the subperiosteal bone.

Whether or not the periosteum is truly osteogenetic depends on whether or not the osteoblasts have origin from the cells of its deep layer or whether they come from without. One fact is self evident, and that is that the periosteum and subperiosteal bone antedate the appearance of marrow, and therefore it can be said that the first subperiosteal bone does not have origin from marrow. The vascular tufts growing into the cartilaginous diaphysis of the fetal femur are the marrow bearing agents, and therefore the first marrow comes from the outside, and enters with the blood vessels from the periosteum. What is the source of these first osteogenetic and medullary elements?

The notions regarding the origin of osteoblasts are several and varied. The fate of the cartilage cells of the cartilaginous diaphysis of the long bones during fetal development is not positively known. Whether or not they are capable of taking on the function of osteoblasts is extremely doubtful, as they apparently degenerate and disappear.

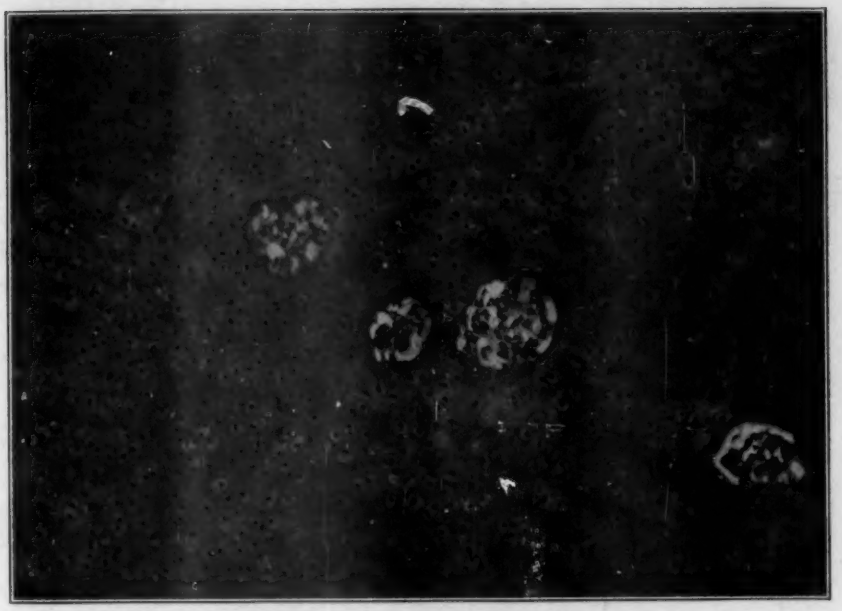

Fig. 7.—Vascular ramifications in central part of a cartilaginous talus, showing evenness in distribution and the size of the cartilage cells, taken from the same fetus as Figure 5. From the collection of the Laboratory of Surgical Pathology.

Fig. 8.—Sagittal section of knee of stillborn human fetus at full term, showing a vascular perichondral bud that has penetrated deeply in distal epiphysis of right femur: *A*, center of ossification; *B*, vascular perichondrial bud; *C*, hyaline cartilage in which matrix between cells has stained deeply; *D*, perichondrium; *E*, superficial area where matrix stains less heavily; *F*, outer and abruptly formed limit of enlarged cartilage cells at border of center of ossification.

According to Geddes,[3] the osteoblasts arise from cells of the ectoderm and migrate as individuals to the sites of bone formation, passing through the periosteum en route. He does not consider the periosteum as osteogenetic. On the other hand, the cartilage cells of the epiphyses of the fetal long bones do not all show degenerative changes; many apparently become free in the tissue of the ingrowing vascular bud from the perichondrium; therefore, it is possible that they may survive and play some part in osteogenesis as osteoblasts, or, according to Geddes,[3] fuse to form osteoclasts.

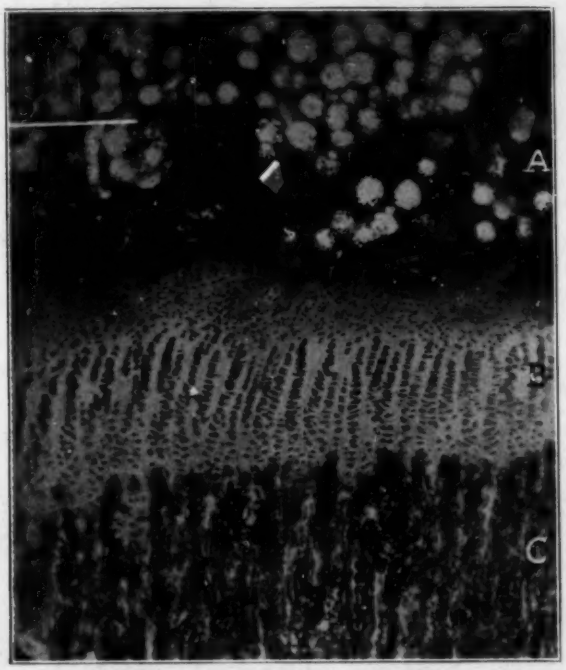

Fig. 9.—Sagittal section of distal end of metatarsal bone of young dog: *A*, epiphysis; *B*, epiphyseal plate; *C*, metaphysis; *D*, fatty marrow; characteristic changes in cartilage beyond borderline of advancing ossification.

Other views are that the osteoblasts are brought to the periosteum by the blood vessels, or that they migrate into it; also, that osteogenetic cells arise directly from embryonic or early connective tissue cells in the deep layer of the periosteum.

It is therefore evident that the origin of the primitive osteoblasts and primitive marrow cells must be sought for outside the domains of the cartilaginous skeleton. Bardeen [4] states that "subperiosteal bone is

3. Geddes, A. C.: The Origin of the Osteoblast and of the Osteoclast, J. Anat. & Physiol. **47**:159, 1912-1913.

4. Bardeen, cited in Keibel and Mall (Footnote 2).

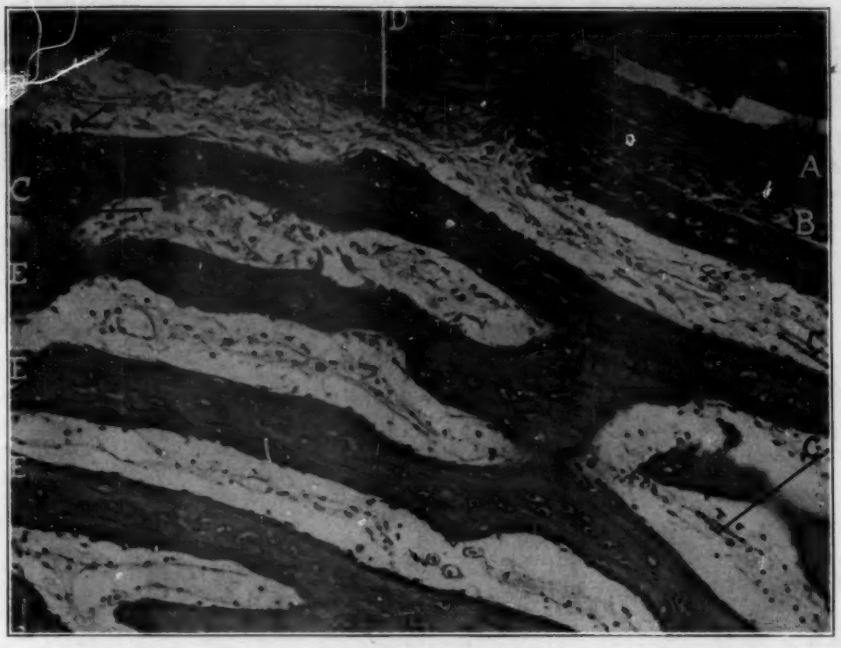

Fig. 10.—Part of longitudinal section of femur of human fetus after about 121 days of development: vertex breach measurement, 13.5 cm., showing character of cortex at middle of diaphysis; *A*, periosteum; *B*, osteogenetic or cellular layer; *C*, wide haversian space opening broadly beneath periosteum, *D*; *E*, bone; hematoxylon and eosin stain.

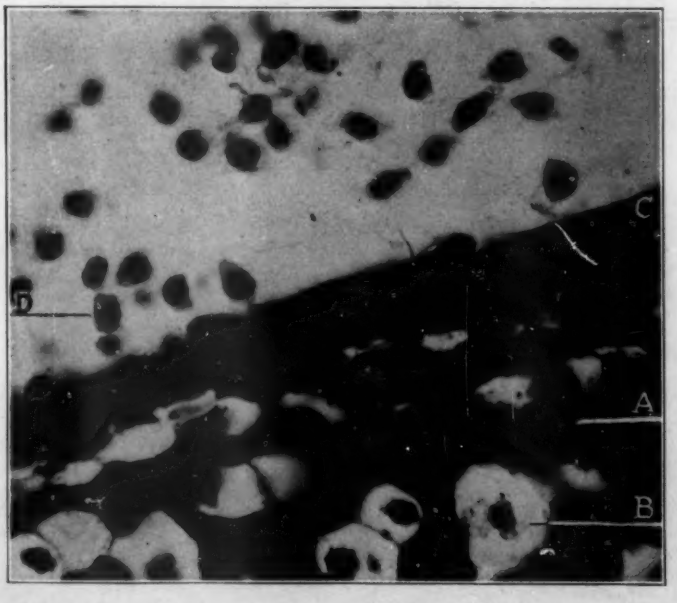

Fig. 11.—Portion of Figure 4 more highly magnified, showing osteoblasts as they are in relation to newly formed subperichondrial bone: *A*, calcified cartilaginous matrix; *B*, cartilage cells; *C*, subperichondrial bone; *D*, osteoblasts; hematoxylon and eosin stain; objective one-twelfth inch; ocular 2 inches.

formed from the deep layer of the periosteum; while in endochondral ossification processes from the osteogenetic layer of the perichondrium or periosteum extend into the substance of the cartilage, and these give rise to destructive and constructive activities which result in the formation of bone."

If one follows Mallory [5] and considers the embryonic connective tissue cells (fibroblasts) as possessing certain potentialities, it becomes easy to understand and to believe that these embryonic cells can become connective tissue cells proper, chondral fibroblasts (chondroblasts) and, finally, mature cartilage cells, osteal fibroblasts (osteoblasts) and finally mature bone cells. It is then quite easy to understand how the cellular layer of the periosteum can be osteogenetic. The study of healing fractures emphasizes this conception of the fibroblastic potentialities.

To those who conceive that the marrow is the source of this osteogenetic function, it is easy to see how the marrow cells can reach the spaces of the so-called cellular layer of the periosteum by way of the haversian canals that open on the surface of the cortical bone. On the other hand, it is no more difficult for osteogenetic cells of the periosteum to reach the marrow cavity and to intermingle with the medullary elements proper than it is vice versa.

From what has been said earlier in this thesis, it is clear that the periosteum as an osteogenetic factor antedates that of the origin of the marrow. The origin of the marrow has been mentioned incidentally.

SUMMARY

The foregoing photomicrographic demonstrations and citations warrant the following statements:

1. During the fetal development of long bones of the extremities, the first bone is deposited by the perichondrium (subperichondral bone); with the change of function, the perichondrium becomes periosteum (subperiosteal bone).

2. The first bone formed in the extremities of a fetus antedates the appearance of marrow.

3. Therefore, at these periods, the perichondrium (periosteum) is osteogenetic.

4. It is acknowledged, histologically, that the perichondrium and periosteum both consist of two layers: an outer or fibrous layer (limiting membrane) and an inner cellular layer (cambium or osteogenetic layer).

5. There is reason to consider the periosteum once osteogenetic always osteogenetic.

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5. Mallory, F. B.: Principles of Pathologic Histology, 1914.

6. The first medullary elements enter the cartilaginous diaphysis of a long bone in the vascular tufts or buds from the periosteum.

7. Likewise, the first osteogenetic elements enter the cartilaginous diaphysis of a long bone with the vascular tufts or buds from the periosteum.

8. There is reason to admit that the subperiosteal osteogenetic elements can enter the medullary cavity and intermingle with the marrow cells of long bones, by way of the haversian canals in fetuses and at any subsequent period during the life of the person, and to supply osteogenetic elements to the marrow; and that the embryonic connective tissue cells of the marrow can also proliferate to supply those elements.

9. There is reason to admit that the osteogenetic elements of the marrow can pass outward in the haversian canals to the cambium layer of the periosteum.

10. There is no reason to deny that experimentation has demonstrated the periosteum to be osteogenetic.

11. There is no reason to deny that the marrow of adults contains osteogenetic elements derived from the perichondrium or periosteum.

12. There is no reason to deny that the embryonic connective tissue cell (fibroblast) is present in the cambium layer of the perichondrium and periosteum, reticulum of the marrow, and areolar tissue about the medullary blood vessels. Observations show that fibroblastic activity is followed by chondral and osseous changes beneath these membranes and in the marrow of healing fractures.

13. Marrow is "all of the soft tissue within the bone," [6] including the osteogenetic elements originally derived from the early fetal perichondrium (periosteum).

14. Textbooks on histology (Szymonowicz) and on human embryology (Keibel and Mall) give facts in accordance with most of the foregoing statements. They state that the histologic structure of marrow includes a delicate fibrous connective tissue sustentacular reticulum, a reticular medullary membrane (endosteum), marrow cells of different types, fat cells according to variety, and blood vessels with their accompanying areolar connective tissue and attending nerves and lymphatics.

15. In conclusion, it is suggested that greater consideration be given to the function of the perichondrium and periosteum, during fetal development, by those who indulge in discussion and debate regarding the osteogenetic function of those membranes.

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6. Ely, L. W.: Inflammation in Bones and Joints, Philadelphia, J. B. Lippincott Company, 1923.

THE USE OF THE SEASPONGE AS A SURGICAL DRESSING*

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A review of the history of the seasponge shows that this substance has long been employed for various medical and surgical purposes, but as far as we have been able to ascertain never until quite recently has it been deliberately used as a dressing for clean surgical wounds.

The object of this paper is to call attention to the value of the seasponge as a surgical dressing and to give the results of our experience with it.

HISTORY

The knowledge of the seasponge is of great antiquity. Herodotus mentions in Urania (Chapter 8) the celebrated sponge diver Skyllias of Skione, and the sponge is mentioned by Homer in the Odyssey (Song 22, Verse 455), and by Aeschylus in Agamemnon (Verse 1,329).

Aristotle (B. C. 384) gives an account of the contemporaneous theories concerning the vitality of the sponge, and gives arguments to prove that it is a sensitive animal, stating that "it voluntarily contracts, clinging more strongly to the rock when an attempt is made to wrench it off." He noted several species and varieties in coarseness and texture, and stated that the firm compact species were used to line sandals and helmets and that Achilles' helmet was thus padded.

Akron, born in Agrigentia (B. C. 504), was a teacher of Empedocles, and practiced during the Peloponnesian wars. He used seasponges cut in long strips as drains in abscesses, but made the interesting observation that they should never be used in clean wounds because there they always caused an infection.[1]

Pliny the Elder (A. D. 23-79) describes in his Natural History,[2] Book ix, Chapter 69, many of the sponges found in the Mediterranean

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* From the surgical department of the Johns Hopkins University Medical Department and Hospital.

* Read before the Southern Surgical Association, Charleston, S. C., Dec. 11, 1924.

1. Gurlt: Geschichte der Chirurgie.

2. Secundus, C. Plinias: Naturall Historie, Translated by Philemon Holland, Doctor in Physicke, London, 1601, 2, Book XXX, Chap. 1, Sec. 1.

Sea, and he classes them as being between animal and vegetable, "bodies which have one half the nature of animal and vegetable." He also gives many observations on the remedies derived from sponges.

> Those which grow upon a northeastern aspect are preferred, the physicians assuring us that these retain the breath of life the longest of all, which makes them most useful to the human body, from the union which is thereby affected, of the vital principle with our own. For this reason they are prepared as fresh as possible and in a moist state rather than in a dry one. They are used for cleansing wounds and sores and as fomentations. The ashes are recommended for patients suffering from discharges of blood and topically applied to the forehead cure tertian fevers.

Celsus (about B. C. 7-A. D. 54) in his "De re medicina," Book vii, deals with things surgical, such as ligatures and bandages, and recommends in the treatment of hemorrhage that "after the wound has been filled with lint, a sponge dipped in cold water should be applied over the lint and pressed upon the part, with the hand." This is the first mention of the surgical principle—compression—in checking hemorrhage.[3]

In this connection, it is interesting to note a practice that existed among the Samoan Islanders, in dealing with arrow wounds, which was noted by an English sea captain in 1792 and is related by Prichard.[4] The Samoans took a seasponge which had been compressed when wet and which had been allowed to dry in that condition, and bound it tightly over the bleeding wound, after which the sponge was wet, which caused it to expand and exert pressure on the bleeding area. Whether this was a native discovery or whether they acquired the knowledge from visitors to their islands cannot be ascertained. At any rate, it is clear that these islanders used the dry and compressed sponge as a means of exerting pressure locally, long before this property was made use of either in this country or in Europe.

The ashes of burned sponges were for centuries used as a medicine to be taken internally. They were thought to be efficacious for St. Anthony's fire (erysipelas), goiter, scrofulous glands and various urinary disturbances. The discovery of iodin, in 1812, and the establishment of its medicinal qualities, in 1820, forever set aside as a medicinal agent, sponge ash, which undoubtedly had been beneficial for the small amounts of iodin and bromid contained in it.

In 1866, Drs. Bachelder and S. Conant Foster of New York first made use of the elastic properties of shaped pieces of compressed dried sponge for dilating the uterine cervix, strictures of the urethra and rectum, sinus tracts and the nasal and auditory canals. They also used

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3. Broca, P.: Fac. de med. d. Paris Confer. Histor., 1866, pp. 445-497.

4. Prichard, W. T.: Memoirs, Tr. Anthropological Society of London **1,** 1863.

large pieces of sponge dried under pressure. These were firmly bound in place over malignant tumors, and were allowed to swell by the gradual absorption of water into the meshes of the sponge, thereby causing strong, gradual pressure, "which often produces absorption of tumors, gatherings and inflammations of the breast, as well as dilatations of the various passages when properly placed." [5]

For several years, this use of the sponge was popular in America and Europe, but gradually fell into disfavor because of frequent pressure necroses and the inability to control or gauge the amount of pressure.

Hamilton [6] of Edinburgh, in 1880-1881, used a thin layer of fine meshed sponge for stimulating the growth of granulations in sluggish

Fig. 1.—Cast of nose made by packing two moist seasponges into a plaster mold, illustrating use of sponge in accurately filling irregular defects, and showing that every detail is reproduced when the sponge dries out.

ulcers, and called his method "sponge grafting." He found that the interspaces of the sponge soon became filled with granulation tissue and eventually the entire mass became cicatrized. The sponge itself gradually disappeared. "Sponge grafting" was employed extensively for some years after this report, but gradually lost its popularity.

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5. Bachelder, J. P.: History of the Compressed Sponge as a Remedial Agent for the Treatment of Strictures of the Rectum, Urethra, Etc., New York J. M. **6**:293-331 (June) 1859.

6. Hamilton, D. J.: On Sponge Grafting, Edinburgh M. J. **27**:385, 1881.

In throat operations, seasponges are still frequently used as swabs, and we understand that in certain foreign clinics large seasponges are even now employed for "walling off" in the abdominal cavity. However, in the majority of clinics, both in this country and abroad, folded pledgets of surgical gauze have completely displaced the use of the seasponge.

Vilray Blair [7] first utilized the seasponge as a dressing for skin grafts, in April, 1921. We were soon convinced of its great value for this purpose, and extended its use as a dressing for all sorts of clean wounds, especially those in which localized immobilization and even pressure were advantageous or necessary. Blair writes that he has also "used it on all kinds of dressings where an even pressure over an irregular surface was desired."

SOURCE OF SUPPLY

Climate influences the growth of the sponge, which is most perfect in tropical or subtropical regions. The small and infrequently found sponga compressa and sponga ciliata, however, are found beyond 60 degrees of north latitude on the frozen shores of Greenland. The sponga communis, sponga lacinalosa and sponga usitatissima ("sheepswool") are inhabitants of the American coasts, Mediterranean and Red Seas and the Indian Ocean. Lamouroux has classified marine sponges into 163 species and seven genera. The commercial sponges have a wide distribution in the warmer waters, but the fisheries as at present developed are almost entirely restricted to the Mediterranean Sea, the Caribbean Sea, the Gulf of Mexico and adjacent waters. Recently, attempts have been made to establish a fishery in Australia, and a few sponges have come from the Philippines. The Mediterranean fishery is of considerable antiquity and now produces over half the world's supply. The fisheries of the American coast produce by far the greatest quantity, but predominance of the lower priced varieties reduces the value to about three-fourths that of the Mediterranean fisheries.[8]

For surgical purposes, the "sheepswool" sponge of the Florida Keys and of the Rock Island variety are satisfactory as they combine the proper size and shape with softness, durability, resiliency and absorptiveness. These varieties are moderate in cost as compared with some of the others. The small Turkey cup sponge has a very fine texture, is

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7. Blair, V. P.: The Full Thickness Skin Graft, Ann. Surg. **80**:298 (Sept.) 1924; personal communication to author, Oct. 10, 1924.

8. Moore, H. F.: Commercial Sponges and Sponge Fisheries, Bull. U. S. Bureau of Fisheries, **28**, 1908. Smith, H. M.: The Florida Commercial Sponges, Bull. U. S. Bureau of Fisheries **17**, 1897.

absorptive and most durable, so that when cost and size are not factors to be considered, they may be preferred to the American "sheepswool."

PREPARATION [9]

Seasponges cannot be satisfactorily sterilized either by boiling or in the autoclave, as they shrink markedly and become hard and brittle. We have found the following method of sterilization to be simple and satisfactory. The sponge is washed thoroughly with soap and running water; then immersed in 1:500 mercuric chlorid solution for twenty-four hours. The mercuric chlorid is poured off and replaced with fresh solution of the same strength for a second twenty-four hours. The

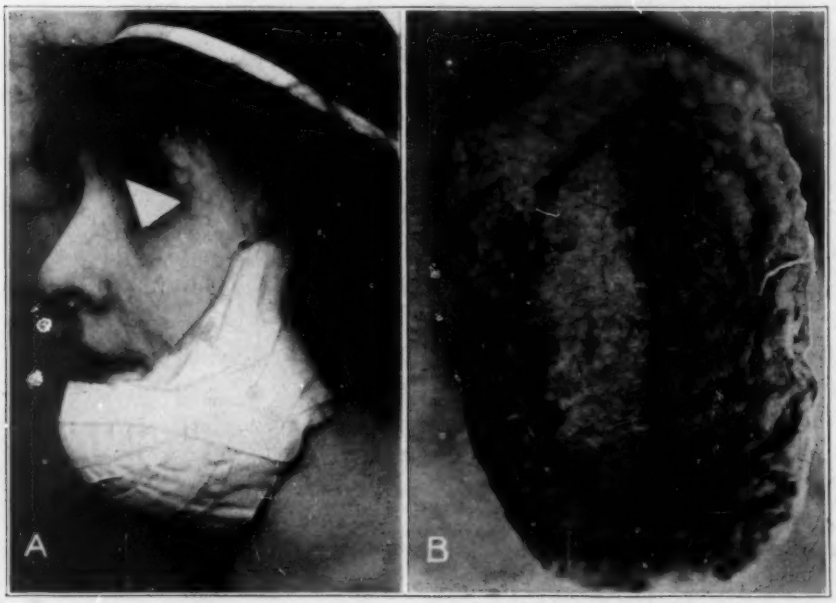

Fig. 2.—*A*, seasponge dressing on large, whole thickness graft, transplanted to repair a chin defect; *B*, same dressing, which was removed after ten days. The outline of the graft, which is indicated by the elongated ellipse of dried blood, should be noted.

sponge is rinsed with sterile water and placed in 70 per cent. alcohol. Numerous laboratory tests on different mediums have shown the sponges prepared in this manner to be sterile. The prepared sponges are stored

9. We use the ordinary commercial bleached American "sheepswool" sponge (6 or 8 inch [15.2 or 20.3 cm.] size), which can be obtained from wholesale druggists.

in 70 per cent. alcohol in tightly covered glass jars, and can be kept for months without deterioration or resterilization.[10]

TECHNIC

Before the sterilized seasponge is applied, it should be rinsed with sterile physiologic sodium chlorid solution to remove the alcohol and then wrung out thoroughly. In order to prevent the seasponge from sticking to the wound after it has dried out, we have found it advantageous before applying the sponge, to place on the wound either gauze impregnated with ointment,[11] perforated cellosilk, rubber protective, rubberized or paraffined mesh, or silverfoil. The choice of material depends on the type of wound.

SUGGESTIONS FOR USE

On a Sluggish Wound.—When the seasponge is used for stimulating granulations, a thin layer, perferably of a fine meshed variety cut to fit the wound, is applied directly to the granulating surface and is held firmly in place by suitable dressings. The wound should be kept as clean as possible by daily dressings, and, if granulations penetrate the meshes of the sponge, it should not be disturbed, as it will eventually be replaced by granulation tissue, the sponge itself being gradually absorbed or thrown off.

On Sutured Wounds.—The sponge may be applied directly to the sutured wound; but we usually prefer to cover the wound smoothly with one or two thicknesses of impregnated gauze or with silverfoil, and immediately over this place the sponge, and press it down firmly. When it is secured in its compressed condition with strips of adhesive plaster or a bandage, gauze should then be applied, and an evenly placed, snug outside bandage. The sponge pressure also should be applied to surrounding undermined areas. The sponge should not be disturbed until it is time to remove the stitches.

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10. Unbleached or stained sponges may be bleached after they have been washed with soap and water by immersing them in 10 per cent. hydrochloric acid for from a half-hour to two hours. The acid should then be removed by thorough rinsing in running water.

Sponges that have been used for dressing clean wounds may be washed and resterilized, and are effective as long as they retain their resiliency.

11. Gauze may be impregnated with either plain petrolatum, or xeroform (tribromphenol bismuth) ointment, 3 per cent. or 4 per cent., or with zinc oxid ointment. Blair prefers xeroform ointment and we have found it excellent. We find it convenient to prepare and sterilize the impregnated gauze in flat tin cases exactly as we do the gauze prepared with petrolatum used for the protection of the skin from surgical solution of chlorinated soda (Dakin's solution). If desired, the sterilized ointment may be thoroughly rubbed into the gauze just before it is used.

On Small Deep Grafts.—When the grafts are properly placed on a fresh wound or on a granulating surface, they may be covered either with overlapping strips of rubber protective, or perforated cellosilk, or rubberized or paraffin mesh, or a single thickness of impregnated gauze. Then the seasponge should be applied, pressed down firmly, and secured as previously described. It is usually advantageous to examine the grafts placed on a granulating wound in forty-eight hours, then to dress with a fresh sponge. On a fresh wound, the grafts may be left undisturbed for one week.

On Ollier-Thiersch Grafts.—Ollier-Thiersch grafts should be covered with silverfoil, impregnated gauze or any other desired material, and then a seasponge placed over the entire area and held snugly in

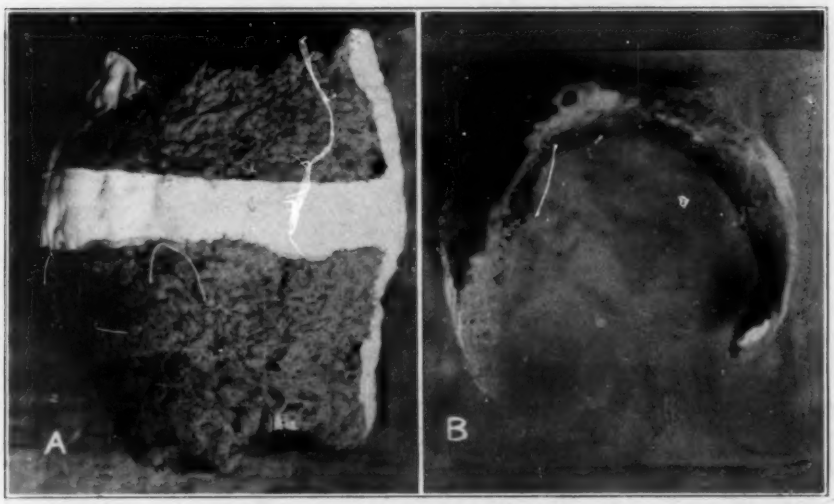

Fig. 3.—Seasponge dressing used to immobolize small deep grafts placed on an extensive denuded area on the leg; *A*, view from above; *B*, profile appearance.

position. This causes apposition of the graft with every part of the underlying surface. The dressing should remain untouched for at least ten days, and preferably for two weeks.

On Whole Thickness Grafts.—The whole thickness graft, which has been sutured into position, should be covered with one or two layers of impregnated gauze, applied very smoothly, and over this a sponge placed. The sponge should be pressed down snugly, so that there is even pressure on every portion of the graft, and secured. The sponge dressing should not be disturbed for at least two weeks, and preferably three. This dressing is particuluarly advantageous on this type of graft.

COMMENTS

The finer the texture of the sponge, the more accurately it can be made to fit into surface irregularities, but the cheaper, wider celled, commercial bleached "sheepswool" sponges are very satisfactory for all practical purposes.

In any position where two surfaces must be kept in close approximation by even, elastic pressure, but where pressure slough must be avoided, we have found the sponge ideal.

When the area to be dressed is depressed or has a very irregular surface, it is advisable to fill it in completely and firmly with either a single shaped piece of sponge or with a number of smaller pieces, and over this packed in space, to place a sponge considerably larger than the surface it is to cover and thick enough to allow firm compression. When the area is large or very deep, it may be necessary to use more than one sponge in order to obtain proper even pressure. We have used as many as six large sponges on a single area. A considerable amount of elastic pressure can be made with a moist seasponge without the danger of a pressure slough, in fact, more than can be safely applied with any other dressing material. We have never seen a slough due to pressure under a moist seasponge that is properly applied, but experience only can show the exact amount of pressure to apply.

Adhesive plaster and bandages over the sponge must be applied so that the pressure is even and directly downward toward the wound. A smearing pull of either of these may entirely spoil the effectiveness of the dressing by exerting uneven pressure, by wrinkling the underlying gauze, and where skin grafts are concerned, by displacing them.

We frequently remove the outside bandage after a few hours, and depend on the adhesive plaster or inner bandage to maintain pressure and to keep the sponge in proper position. This is unnecessary, however, in many instances, and the entire dressing may be left undisturbed as long as desired.

When suturing into position grafts, which are to be left under the seasponge for two or three weeks, we always use horse hair for the suture material.

One of the main advantages of the seasponge as a dressing is that it immobilizes the area so covered. This is particularly important in dressing grafted areas or areas into which implants have been placed.

The portion of the sponge next to the wound stays moist long enough, several days when a 6 inch (15.2 cm.) sponge is used, to absorb any oozing from the wound. When the sponge dries out and is removed, the exact mold of the surface on which it has been is found, and this mold is rigid enough to splint the area satisfactorily. If gauze impreg-

nated with ointment is used between the wound and the sponge, there is usually little difficulty in removing the dry sponge; otherwise, stitches may stick to it.

A moist sponge can be packed down into any kind of crevice or depression and, when it drys, will completely fill the cavity and splint the surrounding walls. When the sponge has been packed into depressions or behind rigid projections, it may be difficult to remove after it is dry unless thoroughly soaked with sterile water or physiologic sodium chlorid solution.

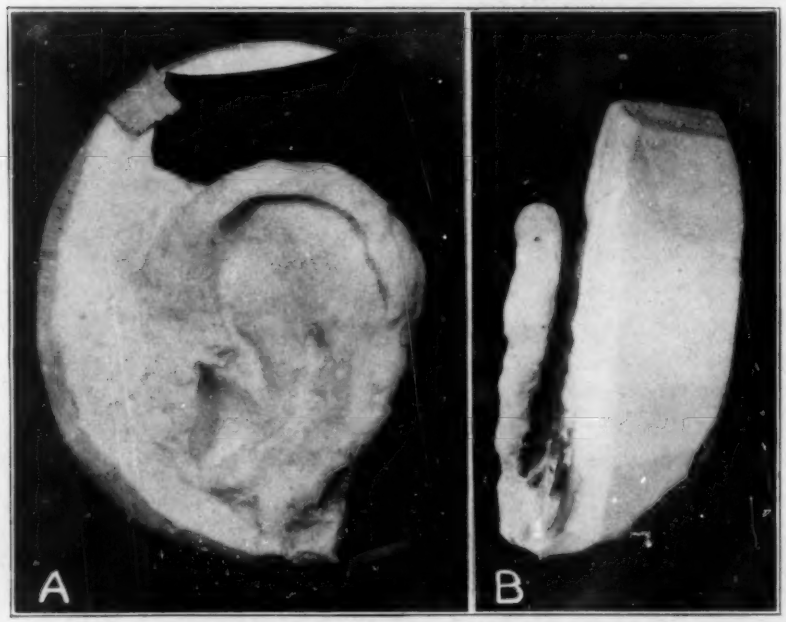

Fig. 4.—Plaster cast of portion of ear made directly from seasponge dressing, which had been in place for ten days; *A*, side view; *B*, appearance from behind.

When dealing with wounds of the groin, popliteal or cubital space, in children, it is sometimes advisable to place a plaster cast or crinoline bandage over the sponge dressing.

We have, on several occasions, placed seasponges under pressure over perforated cellosilk on large, freshly denuded areas and allowed them to stay in place for two weeks without being disturbed, and have then found the wounds fresh and clean, covered with flat, healthy granulations. We have found the firm pressure exerted by the seasponge very advantageous in checking the bleeding from stitch holes and sutured wound margins after partial excision of extensive angiomatous areas.

The seasponge can be employed to advantage in packing the axilla and exerting even pressure over the undermined areas after radical breast operations, also after extensive neck dissections. Even sponge pressure is very useful as a dressing on oozing scalp flaps. In operations for syndactylism, either congenital or acquired, the fingers can be kept apart and safely immobilized and the newly formed commissures be accurately splinted with a seasponge. It also is very useful as a dressing after other plastic operations on the hands.

When a flap is lined with an Ollier-Thiersch or whole thickness graft in a delayed transfer, the even pressure of a seasponge is invaluable for preventing oozing and for immobilizing the part.

On the nose after plastic operations or transplantations, we find it a very useful dressing.

Over irregular surfaces like the ear, after plastic operations, every depression should be packed full of small bits of seasponge and after this has been done, front and back, then a large sponge should be placed over the whole, compressed and secured with adhesive plaster and bandage. When the sponge dries out, it absolutely splints the ear and forms a very light cast. We have found it useful when dealing with hematoma auris and in many other procedures in which snug support and even pressure are essential. In these cases it takes the place of plaster-of-Paris, is much easier to apply, and more comfortable for the patient.

The use of the compressed dry sponge for exerting even pressure around joints is an old procedure and very valuable if properly used. Wet sponges are flattened in a press and allowed to dry; they are then placed around the joint or over the area desired and secured with a bandage. Water is poured over the dressing, and the swelling of the sponge will cause even pressure. The danger in this procedure is that, unless care is taken, too much pressure may take place and sloughing follow.

The seasponge makes a very satisfactory dressing after straightening the penis in the preliminary operation for the relief of hypospadias. When a seasponge dressing is used in any region where infection is difficult to combat, such as around the mouth, the dressing should be inspected frequently and changed when necessary. Should the sponge have to be removed for any purpose, a fresh sponge should be applied just as at the original dressing. Even pressure may be obtained by a properly secured rubber sponge, but, as it macerates and draws the skin, it cannot be kept in place for any considerable length of time.

SUMMARY

The seasponge is easy to obtain and can be sterilized without difficulty. It can be applied under considerable pressure that is elastic, even and continuous, with little danger of a pressure slough. It minimizes congestion in flaps and grafts. By its use, dead spaces are eliminated. It stays moist long enough to absorb any blood or serum that may ooze from the wound. It does not irritate or macerate the skin even after being in place for weeks.

The moist seasponge, under pressure, fits into depressions and over uneven surfaces more accurately than any other dressing material with which we are familiar. When it dries, it forms a perfect mold of the surface and absolutely splints and immobilizes the area over which it is applied. It is particularly valuable as a dressing after plastic operations of various kinds and for skin grafts, especially of the whole thickness variety. In addition, we have used the seasponge with satisfaction on wounds requiring even pressure and immobilization on all parts of the body, and find it a most valuable surgical dressing.

STRATIFIED SQUAMOUS CELL CARCINOMA OF THE BODY OF THE UTERUS *

EDWIN F. HIRSCH, M.D.

CHICAGO

Carcinomas arising in the fundus of the uterus commonly contain cells that repeat essentially the characteristics of the lining columnar epithelium, in varying degrees of differentiation. Where the differentiation of the cells has occurred to a marked degree, there are present gland-like or papillary structures. However, there are other varieties of fundic carcinomas in which the cell arrangement differs, in that along with the columnar epithelium there are present masses of cells having the appearance of squamous cells. In fact, some tumors seem to consist only of such squamous epithelium, stratified in layers as in the epidermis, and containing masses of these cells in varying degrees of hornification. At present, the origin of the squamous cells is regarded as a metaplasia, but such an explanation regarding them has not always been the one offered or accepted.

Probably the first record of squamous cells in adenocarcinoma of the uterus was made by Breisky [1] in 1877. He observed cell masses in a tumor of the uterine lining, which peripherally consisted of cylindrical cells and centrally of squamous cells. A similar, but somewhat later, observation was made by Ruge and Veit,[2] and since then a considerable number have been reported in the German medical journals, but very few in the American. At first, these mixed forms of fundic carcinoma were thought to arise from separate matrices; that is, it was thought that they were carcinomas containing proliferating cells from both the surface and the glandular epithelium. This, of course, implied a double carcinoma. However, as early as 1901, Emanuel [3] concluded that the primary tumor is always glandular, and that the columnar epithelium becomes changed by metaplasia into squamous epithelium. The last mentioned cells multiply to form the squamous cell carcinoma.

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* From the Pathological Laboratory of St. Luke's Hospital.

1. Breisky: Ueber adenome des Uterus, Prag. med. Wchnschr. **2**:78-79, 1877.

2. Ruge, C., and Veit, J.: Der Krebs der Gebarmutter, Ztschr. f. Geburtsh. u. Gynäk. **6**:261-332, 1881.

3. Emanuel, R.: Ueber gleichzeitiges vorkommen von Drusenkrebs und Hornkrebs im Uterus Korper, zugleich ein Beitrag zur Histogenesis der primaren Hornkrebs, Ztschr. f. Geburtsh. u. Gynäk. **46**:434-457, 1901.

Thus far, mention has been made only of the presence of squamous epithelium in carcinomas of the fundus. In 1885, Zeller [4] sought to establish that metaplasia of the columnar cells into squamous epithelium occurs commonly in the uterine mucosa. He reports the presence of prickle cells, an observation regarding the detail of cell structure which most writers since deny for the squamous cells of the corpus uteri. Pinkuss and Ruge [5] questioned this observation. Pinkuss regarded the cells mentioned by Zeller [4] in the curetted fragments of uterine lining as having come from the cervical or vaginal epithelium, while Ruge considered doubtful the report of squamous cells in the fundus. Long before Zeller reported his observation, the presence of squamous cells on the surface of non-malignant uterine polypi was known. Billroth,[6] in 1855, mentions them, and similar observations were made by Küstner [7] and others. Meyer,[8] more recently, has given special attention to the presence of these masses of squamous-like epithelium in the uterine mucosa. He observed masses budding into the lumina of the glands, some having completely filled the lumen. These cells resemble pavement epithelium not only because of the stratification, but also because of their polygonal form and round nuclei. There is not, however, the usual variation of the layers seen in normal squamous epithelium. There are regions, according to the descriptions by Meyer,[8] in which the cylindrical cells, as well as the replacement cells in the deeper portions of the lining, are intimately associated with these masses of pavement epithelium. Other places clearly indicate that the squamous epithelium is basal and that it has pushed out the cylindrical cells, a process of growth similar to that taking place in the formation of a kidney glomerulus. These changes were observed by Meyer in hyperplastic endometritis.

The significance of these cell masses is not uniformly interpreted. Palano,[9] Sitzenfrey,[10] and Englehorn [11] regard them as malignant, while

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4. Zeller, A.: Plattenepithel im Uterus (Ichthyosis uterina), Ztschr. f. Geburtsh. u. Gynäk. **11**:56-88, 1885.

5. Pinkuss and Ruge, C., in A. Doederlein: Die Enzundung der Gebärmutter, Veit's Handbuch der Gynakologie **2**:158-159, 1907.

6. Billroth, Theodor: Ueber den Bau von Schleimpolypen, Berlin, 1855, p. 24.

7. Küstner, O.: Beitrage zur Lehre von der Endometritis, 1883, p. 38.

8. Meyer, Robert: "Plattenepithelknotchen" in Hyperplastischen Drusen der Korpusschleimhaut des Uterus and bei Karcinom, Arch. f. Gynäk. **115**: 394-407 (Nov.) 1922.

9. Polano, Oskar: Zur Pathologie des Uterus, Ztschr. f. Geburtsh. u. Gynäk. **67**:413-429, 1910.

10. Sitzenfrey, A.: Multiple Plattenepithelkarzinomknotchen der Korpusdrusen bei Adenometritis uteri, Gynäk. Rundschau **5**:221-223, 1911.

11. Engelhorn, Ernst: Korpuskarzinom bei einer Dreiundzwanzigjahrigen, Beit. z. Geburtsh. u. Gynäk. **13**:278-284, 1908-1909.

Meyer does not interpret all of them in this way. Meyer, as it has been mentioned, finds these cells rather common in hyperplastic endometritis, and Hunziker [12] mentions them in the uterus with senility, with chronic gonorrhea and other infections.

Recently, Zimmermann [13] continues the discussion on the presence of squamous cells in carcinomas of the fundus. He reports six of these tumors, with squamous cell-like masses representing degenerative forms of malignant cylindrical cells. In these tumors, he describes transitional stages between the typical cylindrical cells, through indifferent forms, to squamous epithelium. These cells contain such marks of degenerative change as swelling, vacuolization, nuclear fragmentation, and even complete solution of the cells. He observed them in intimate relation with masses of cylindrical cells; they had no independent infiltrating growth, and there were none in mitotic division. Zimmermann [13] does not look on these pavement cells as a cylindrical cell metaplasia; he considers them to be cylindrical cells that have changed their form because of local tissue disturbances. Contrasted with these are three carcinomas of the fundus in which squamous epithelial nodes were present under the cylindrical epithelium, exactly as Meyer [8] has described. These cells seem to be actively growing; there are no transitions between them and the cylindrical cells, and Zimmermann thinks that they have developed from undifferentiated lining cells.

The application of the term "squamous" cell to these epithelial forms implies, as Meyer suggests, the establishment of certain definite characteristics, such as the presence of intercellular bridges (prickles), hornification, pearl formation, and the multiplicity of cell layers such as occur in the epidermis. In the epidermal epithelium, of course, these are manifested to a high degree; but in carcinomas of the corpus, one or more of these characters is usually absent. Zeller [4] appears to be the only one who reports the presence of intercellular bridges, the so-called prickle cells.

There seems, then, to be no doubt in regard to the occurrence of these cells, which are generally described as squamous cells, in certain carcinomas of the fundus, as well as in certain nonmalignant changes of the uterine mucosa. Explanations offered to account for their presence are along two lines; namely, degenerative changes of the lining columnar epithelium and metaplasia. The degenerative processes leading to the formation of pavement-like cells need consideration only in so

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12. Hunziker, Hans: Ueber Plattenepithel in der Schleimhaut des Cavum uteri, Frankfurter Ztschr. f. Path. **8**:1-33, 1911.

13. Zimmermann, R.: Ueber Plattenepithelbefunde im Gebarmutterkorperkrebs, Arch. f. Gynäk. **118**:273-295 (April) 1923.

far as Zimmermann has expressed. The process of metaplasia, however, is more complicated; and while many writers have given this as an explanation, there has not been unanimity in regard to the manner in which the metaplasia takes place.

So long as attempts were made to distinguish among corpus carcinomas those arising from surface epithelium and those from glandular, these hornified carcinomas were thought to be derived from the surface cells; their origin was explained by a preceding metaplasia of the cylindrical cells. Hitschmann [14] modified this view by expressing the opinion that not only the surface epithelium, but also the glandular, may undergo metaplasia. With none of these explanations, however, were transitional stages demonstrated and offered as supporting evidence. In a recent comprehensive discussion of metaplasia made by Krompecher,[15] based on his large experience with basal cell tumors, there is emphasized the relation of the basal cell to metaplasia. Most writers, he says, regard metaplasia as a complicated regenerative process concerned primarily with the growth of undifferentiated or slightly differentiated cells. There is considerable question as to whether these indifferent cells are such originally, that is, that they possess the ability of growing directly into cells foreign to the particular tissue, or whether they arise by means of a so-called "misdifferentiation" from normal, fully differentiated cells during mitosis, and, after having begun this perverted growth, continue their development along indirect ways. Metaplasia of cylindrical epithelium into squamous epithelium is intimately concerned with the regeneration of epithelium, and its occurrence is especially evident in simple columnar surfaces. Referring specifically to his report on basal cell carcinomas of the uterus, Krompecher [16] says that there are combination forms of cylindrical cell carcinoma and basal cell carcinoma. The amount of the basal cell elements is usually quite small, so that the tumor is designated as a cylindrical cell carcinoma with secondary partial change into a basal cell. He has described similar combinations of cylindrical cell and basal cell carcinomas in the stomach and the large bowel. These, he says, are the connecting links between the cylindrical cell carcinomas and the basal cell carcinomas. Basal cell masses are present in from 20 to 25 per cent. of all cylindrical cell carcinomas of the uterus; Krompecher reports that these manifest a more

14. Hitschmann, F.: Ein Beitrag zur Kenntniss des Korpuskarzinom, Arch. f. Gynäk. **69**:629-680, 1903.

15. Krompecher, E.: Basalzellen, Metaplasia, und Regeneration, Beitr. z. path. Anat. u. z. allg. Path. **72**:163-183, 1923.

16. Krompecher, E.: Der Basalzellenkrebs des Uterus, Ztschr. f. Geburtsh. u. Gynäk **81**:299-338 (May) 1919.

or less marked metaplasia, in that between the basal cells there are larger flat cells with changes resembling hornification. Krompecher brings into his discussion of the relation of basal cells to metaplasia Kawamura's [17] experimental production of bronchial epithelium metaplasia (cylindrical cells into pavement epithelium) in animals by inflammatory stimulation, as well as the similar changes in bronchial epithelium observed by Goldzieher [18] in laryngeal diphtheria, and the similar observations made by Teutschlaender [19] in rat bronchopneumonia. In the last mentioned observations, the basal cells occurred in masses within the center of cylindrical epithelium aggregations. These were designated "basal cell cumuli." As the ciliated epithelium covering these masses of basal cells passes through degenerative changes and disappears, there forms gradually a transitional epithelium; this hornifies on the surface and possesses the various layers of an epidermis. This is a true metaplasia; and essentially it is a regenerative process with extensive tissue alterations, a so-called anisogenic replacement. This, according to Krompecher, is conceivable only when the cells concerned with the regenerative process possess several growth potentials. Similar observations regarding basal cell growth have been recorded for the pancreatic ducts, the vas deferens, the parotid gland, the breast, and especially for the hyperplastic glands of the uterine mucosa.

The observations mentioned show that, in metaplasia, most authors emphasize the importance of undifferentiated or slightly differentiated cells. These have been so designated without further terminology, or as Krompecher [16] has designated them, "basal" cells. They occur in simple columnar epithelium such as that found in the stomach, bowel, bronchi, endometrium, and in the large excretory ducts of glands; they multiply in these places to form either benign basal cell masses or malignant growths. With either of these growths there may be a metaplasia into squamous cells.

These statements regarding squamous cell carcinomas of the uterine fundus, and those concerning the present status of opinion regarding their origin are given as an introduction to a report of three such tumors observed during the year 1923 in the Gynecological Service (Drs. Thomas J. Watkins and Arthur H. Curtis) at St. Luke's Hos-

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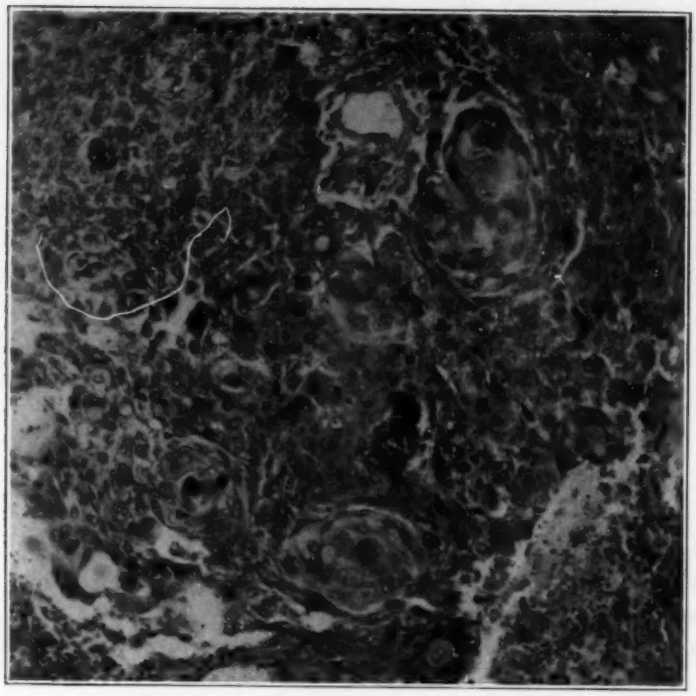

Fig. 1.—Hornified cell mass; × 140.

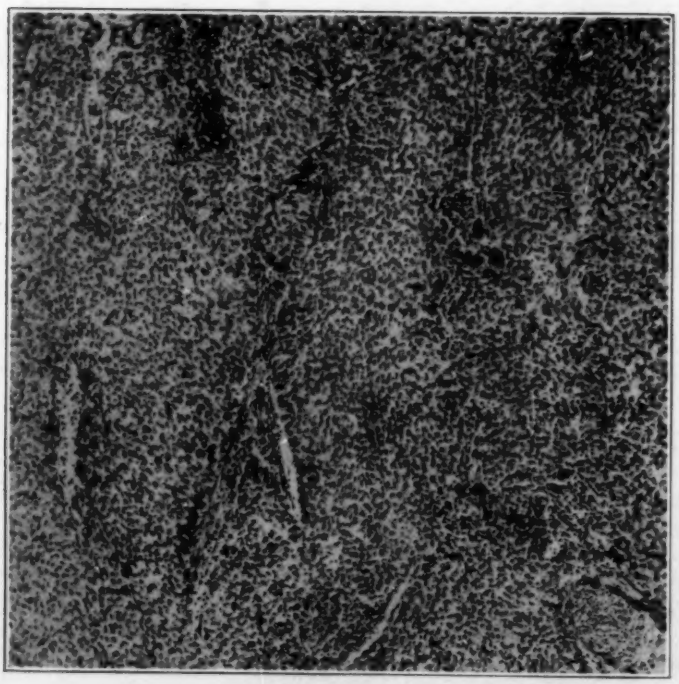

Fig. 2.—Stratification of cells; × 70.

pital, Chicago. They occurred in the uteri of women at, or slightly beyond, middle age, and were removed surgically after a diagnosis of carcinoma had been made. In the sections of these tumors stained with hematoxylin and eosin, there was a proliferation of the epithelium into stratified layers, and the cells, in part, were hornified, some forming pearl-like structures. Stained for keratin granules, certain of the hornified cells were seen to contain masses which reacted specifically, and were accordingly regarded as keratin. The histologic appearance of these tissues is illustrated in the two photomicrographs.

The details of the examinations made of the tissues before fixing are as follows:

SPECIMEN 1.—This complete uterus was 10.5 cm. long, 6 cm. wide and 5 cm. thick. There was smooth mucosa around the external os about 1.5 cm. wide. Both fallopian tubes and ovaries were attached. The tubes were 8 by 0.7 cm. and without noteworthy changes; the ovaries were 3.5 by 2.2 by 1.8 cm. When the uterus was opened in the front half of its sagittal plane, there was demonstrated a cauliflower-like mass completely involving the fundic portion, and infiltrating the muscle practically to the serosa. The tumor tissue was soft, easily torn, gray and yellow.

In the histologic examination, no tumor cells were found in the tissues except in the uterus.

SPECIMEN 2.—This uterus contained tissue from the top of the fundus to the external os inclusive, with mucosa around the external os from 1 to 1.5 cm. wide. The left fallopian tube was attached, 6 by 0.7 cm., and the corresponding ovary 2.5 by 1.5 by 1 cm. When the uterus was opened in the back half of its sagittal plane, there was exposed in the left cornu an irregular bloody mass of friable white tissue, 2 cm. in diameter and 1.5 cm. high. The surfaces were torn. The infiltration of the wall beneath this did not exceed 6 mm., and the muscle thickness altogether was 1.5 cm. There were three small fibromyomas in different parts of the wall. The uterine lining otherwise was roughened (recently curetted) and covered with small, dark red blood clots. Immediately above the external os in the front wall was a surface 6 mm. in diameter slightly elevated and covered with a thin layer of fibrin (radium burn). The right fallopian tube and ovary were present as separate tissues, the tube 5.5 by 0.8 cm., and the ovary 2.5 by 1.5 by 1.5 cm.

In the histologic examination, tissues other than the uterus were not found to contain tumor cells.

SPECIMEN 3.—This uterus was complete, measuring 10.5 by 7 by 5 cm., including the external os and the mucosa around it, 1 cm. wide. The entire fundic portion of the lining, including the uterine cavity, was an irregular cauliflower-like mass of white tissue, easily torn and crushed. This tissue was present on all the internal surfaces and possessed the characteristics of a carcinoma. Both fallopian tubes and ovaries were attached; the tubes were 10 cm. long and 0.8 cm. in diameter, and the ovaries 3 by 1.5 by 1 cm.

No tumor tissue was demonstrated in tissues other than the uterus by the histologic examination.

The interest in these squamous cell carcinomas of the uterus chiefly concerns their histologic structure. They may contain both columnar

and squamous epithelium in varying proportions, with the cells of the latter hornified to a slight or a considerable degree. Tumors made up chiefly or entirely of squamous cells usually have the greatest hornification. In regard to such features as the degree of malignancy, the rapidity of growth, and the prognosis after removal, there are no facts available at present from which definite conclusions may be reached.

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